

1 Online appendix to
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3 **Verification of TIGGE Multi-model and ECMWF**
4 **Reforecast-Calibrated Probabilistic Precipitation**
5 **Forecasts over the Conterminous US**

6 by
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8 Thomas M. Hamill
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13 This online appendix provides additional figures that help provide a
14 more complete set of forecast verification diagnostics.
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Reliability, Day +1 1.0mm

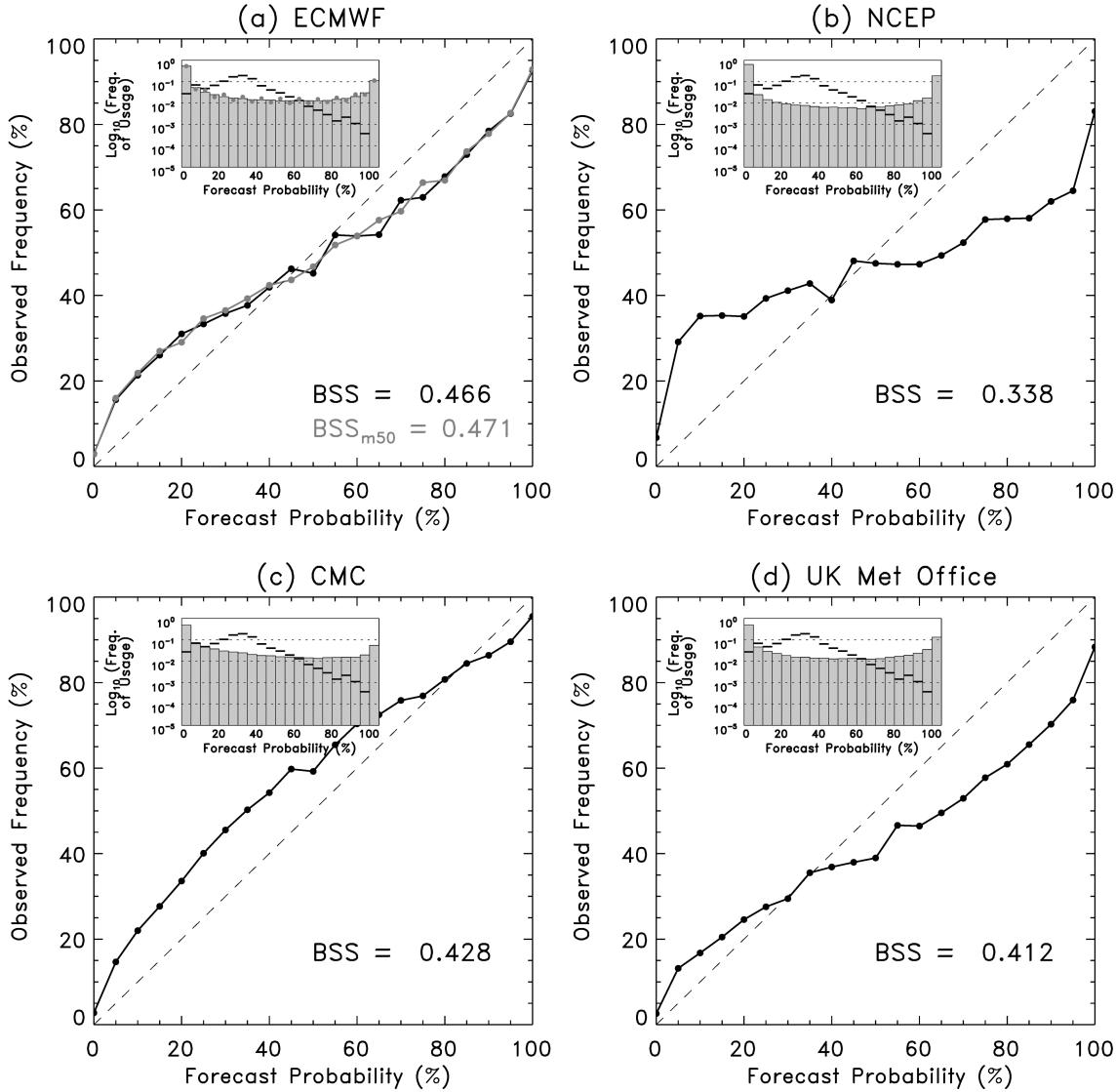
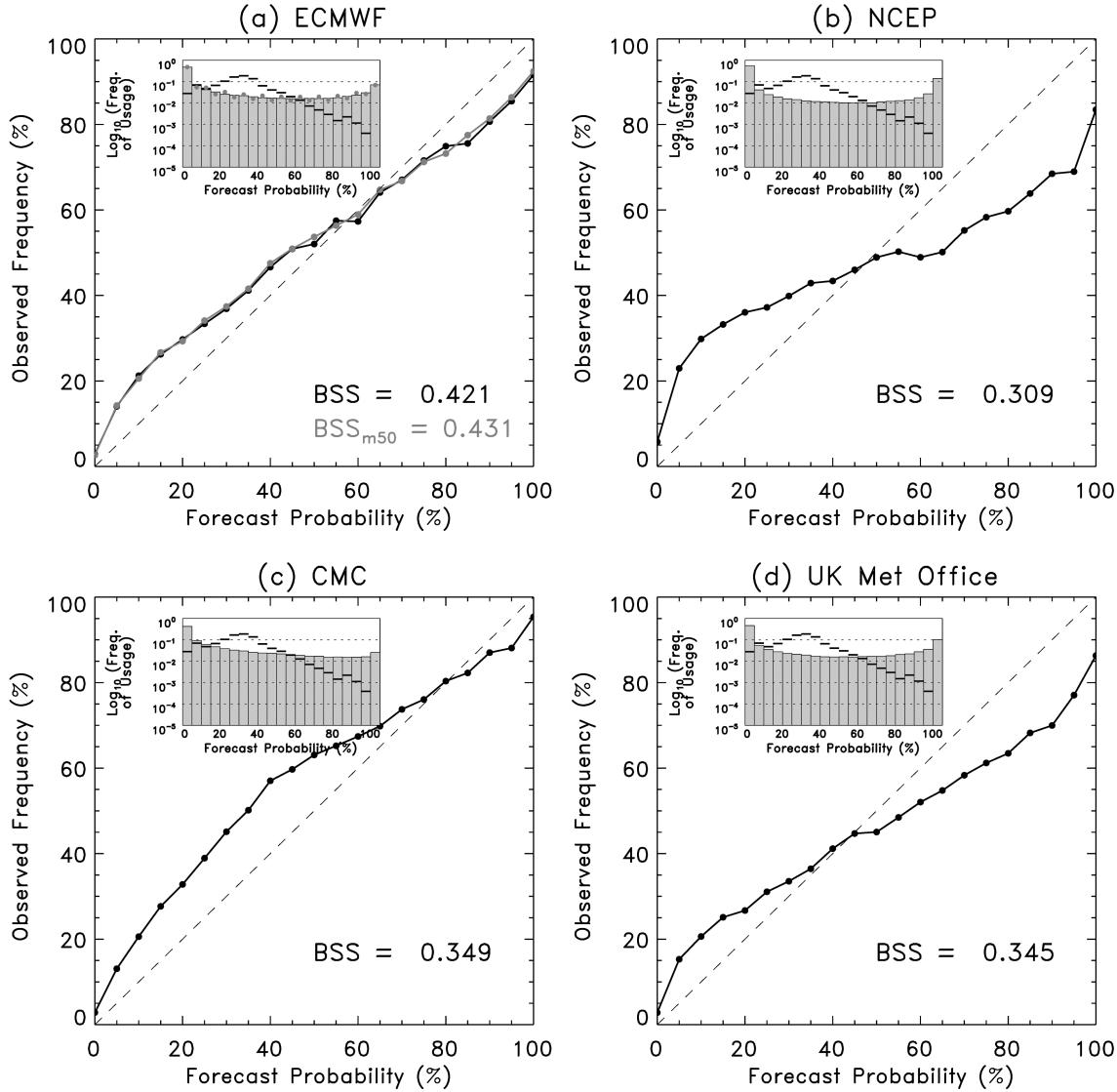


Figure A1: Reliability diagrams for day +1 forecasts, > 1-mm (24 h)⁻¹ event. (a) ECMWF, (b) NCEP, (c) CMC, and (d) UKMO. The dark line on each is the reliability curve. The lighter grey line on panel (a) is the reliability for the 50-member ensemble. The inset histogram bars show the relative frequency of usage for each probability bin. The black lines on the inset are the relative frequency of usage for the climatological distribution across all the sample points. The grey dots on the inset histogram of panel (a) are the relative frequency of usage for the ECMWF full 50-member ensemble.

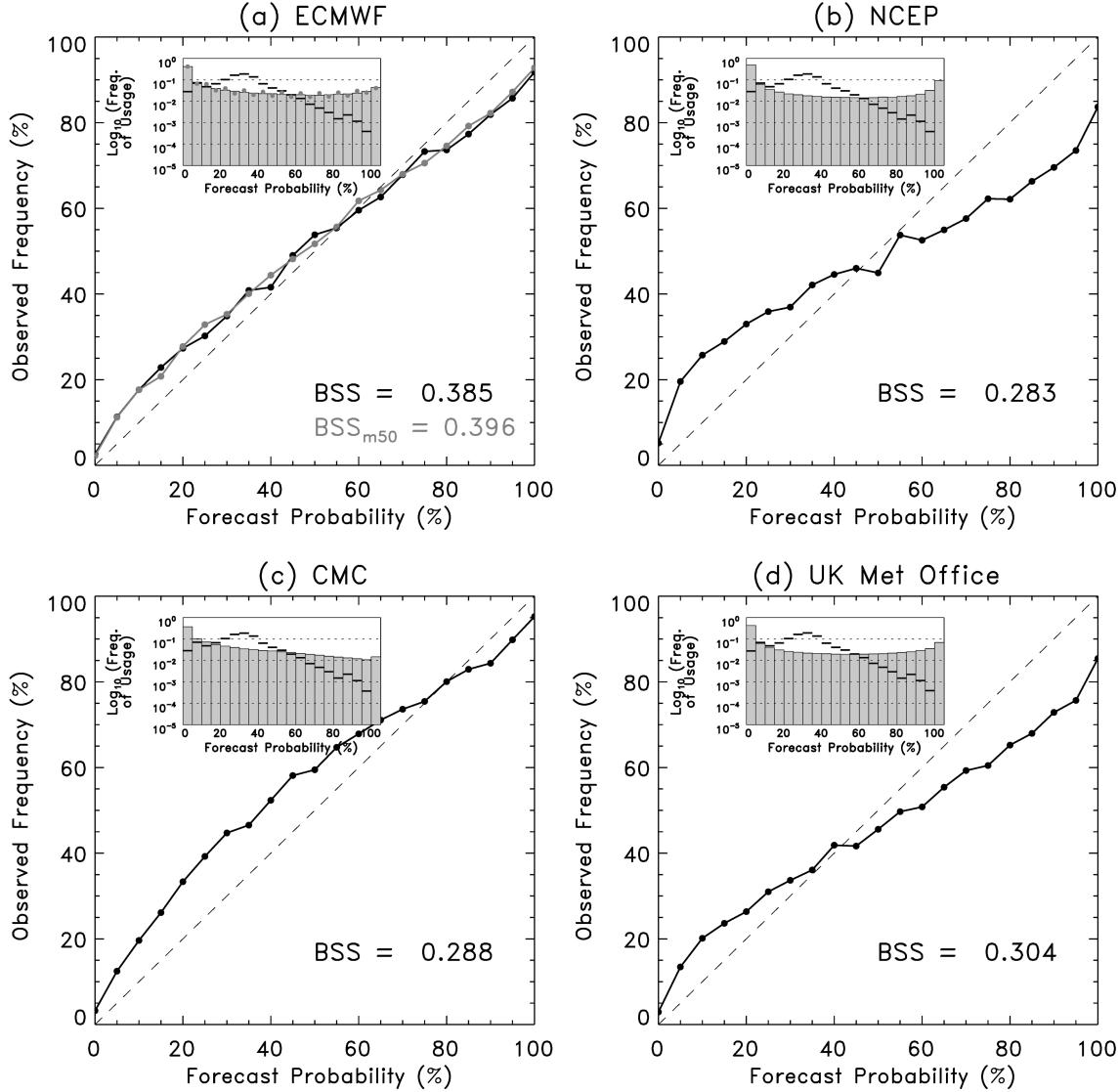
Reliability, Day +2 1.0mm



30 **Figure A2:** As in Fig. A1, but for the day +2 > 1-mm (24 h)⁻¹ forecast.

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Reliability, Day +3 1.0mm



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Figure A3: As in Fig. A1, but for the day +3 > 1-mm (24 h)⁻¹forecast.

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Reliability, Day +4 1.0mm

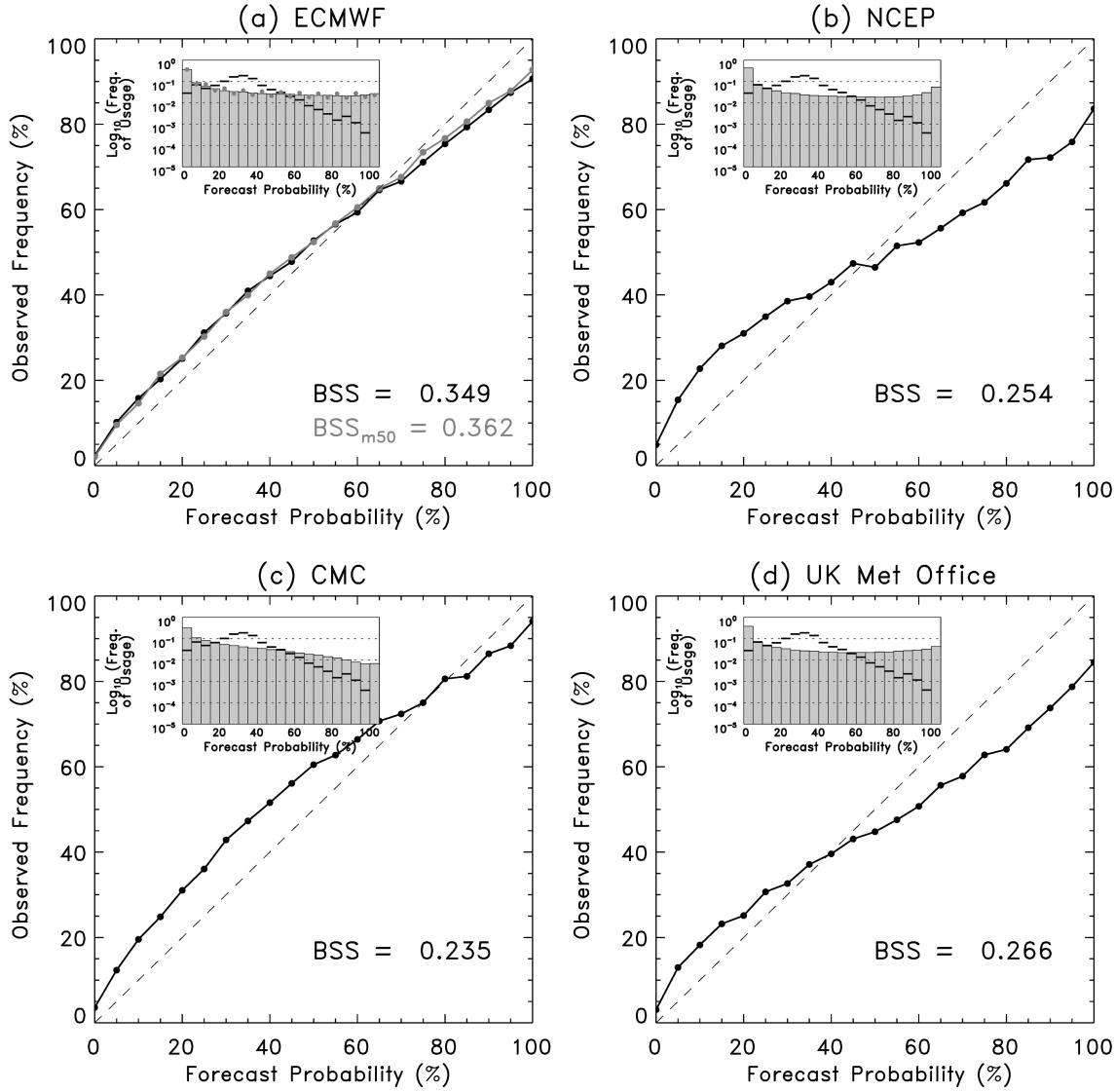
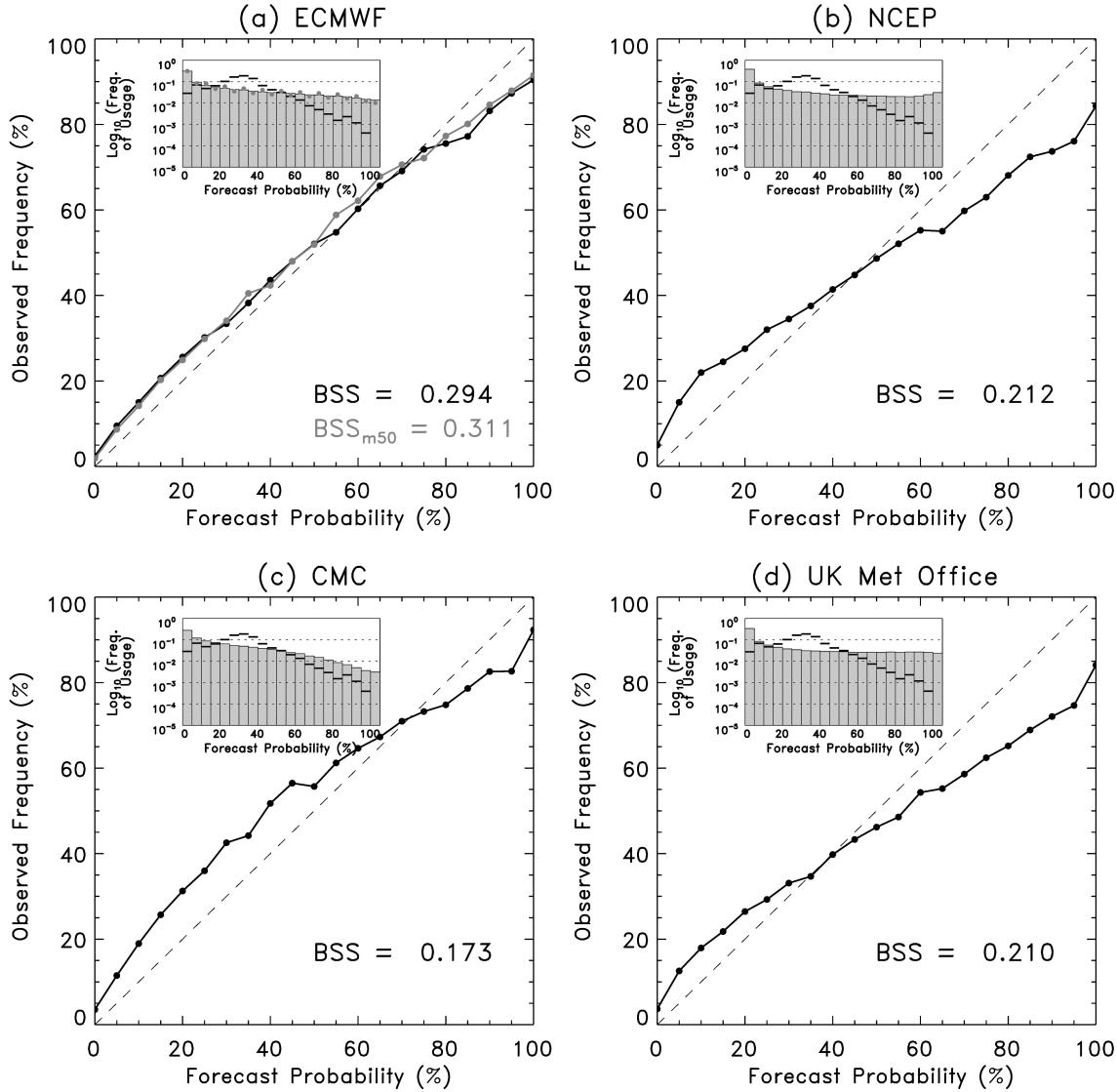
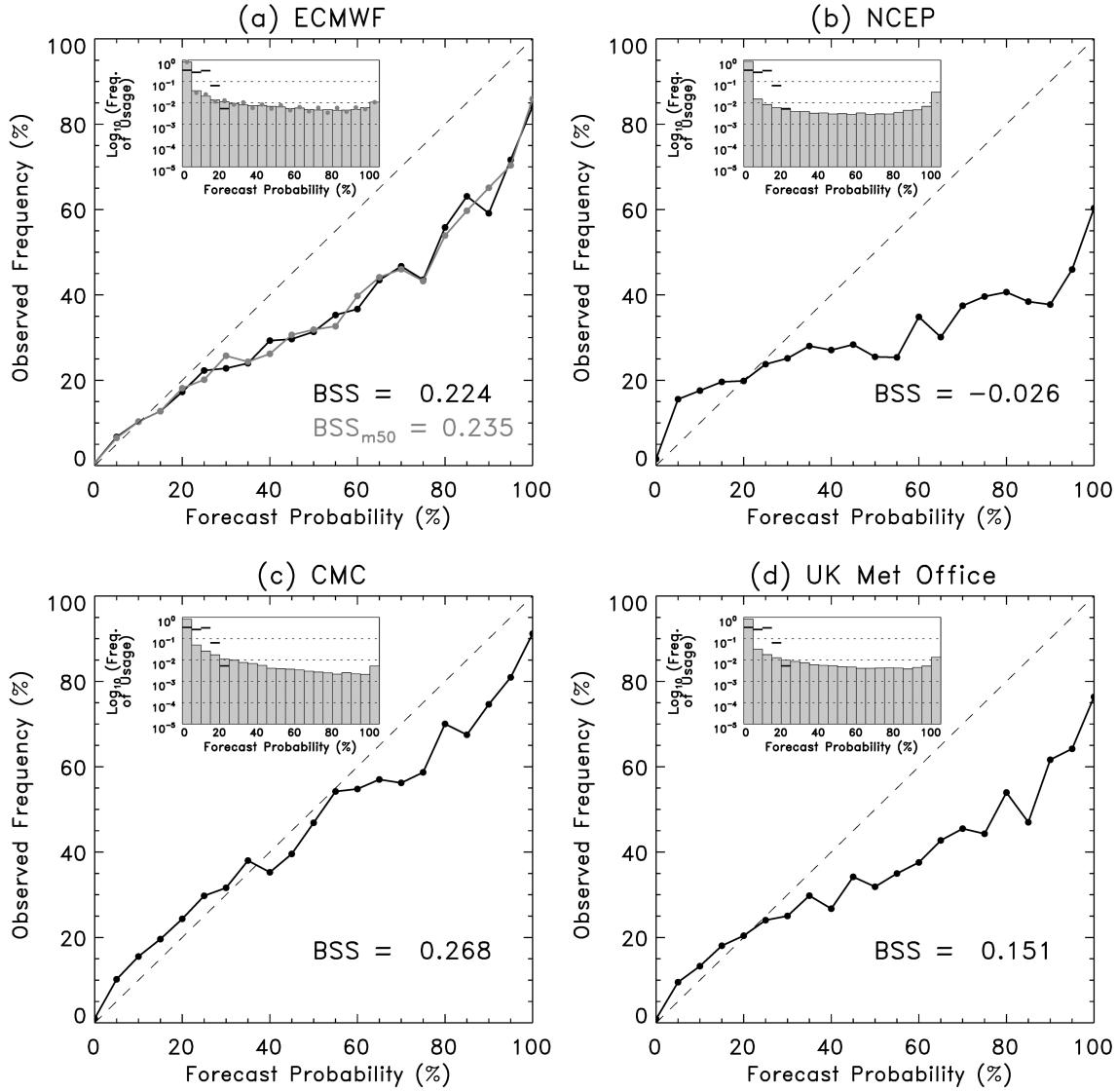


Figure A4: As in Fig. A1, but for the day +4 > 1-mm (24 h)⁻¹ forecast.

Reliability, Day +5 1.0mm

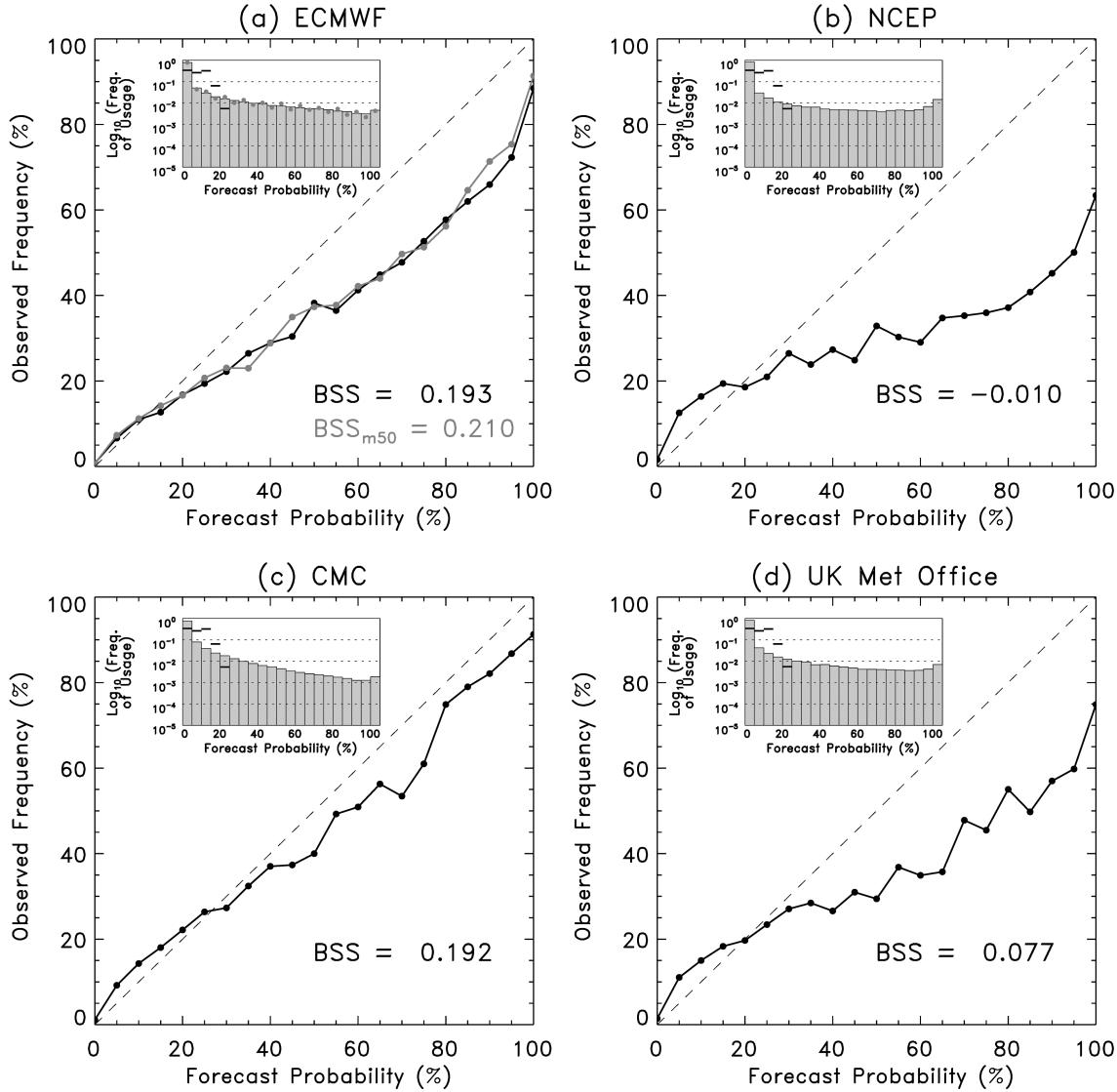


Reliability, Day +1 10.0mm

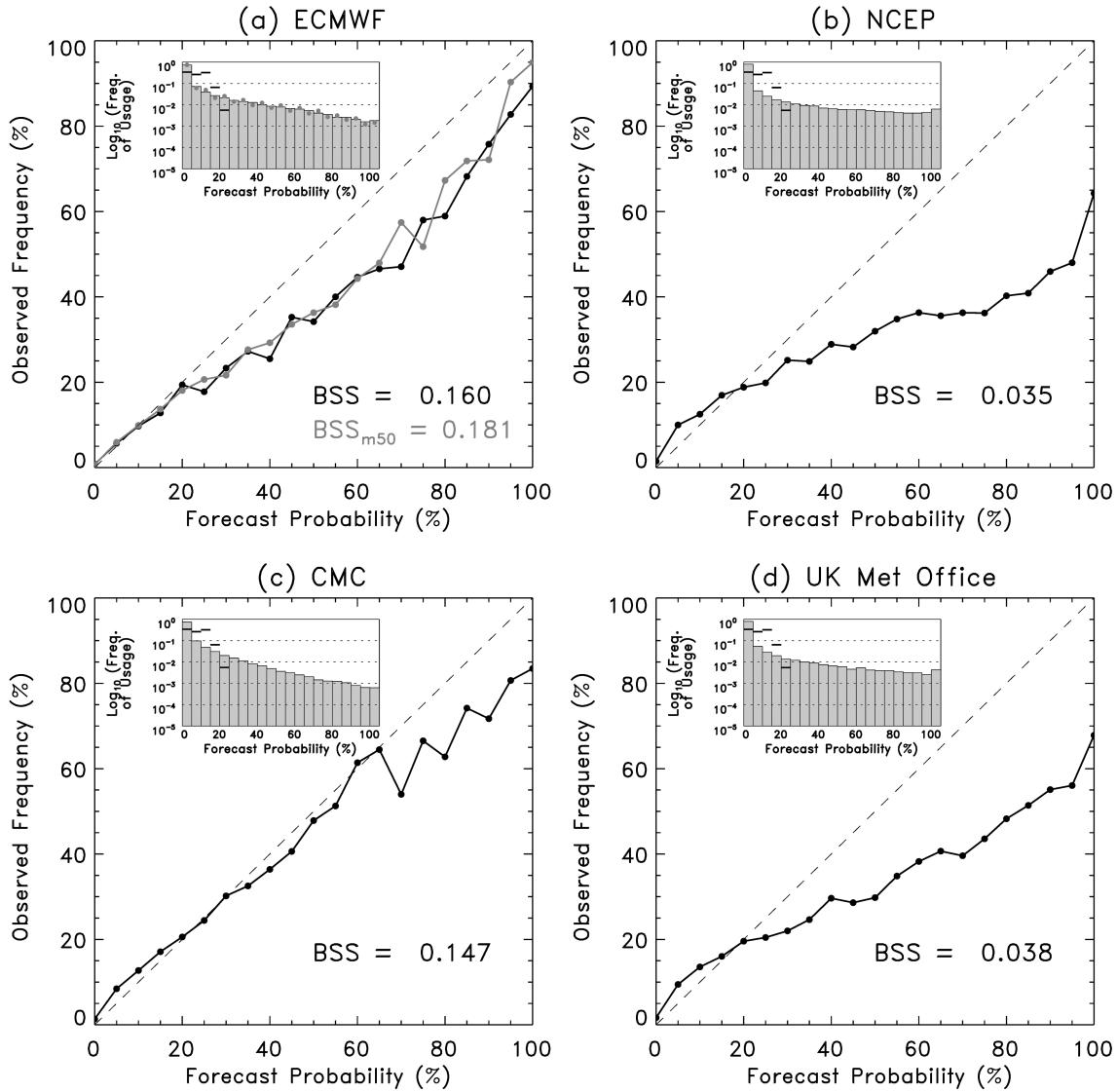


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52 **Figure A6:** As in Fig. A1, but for the day +1 > 10-mm (24 h)⁻¹ forecast.
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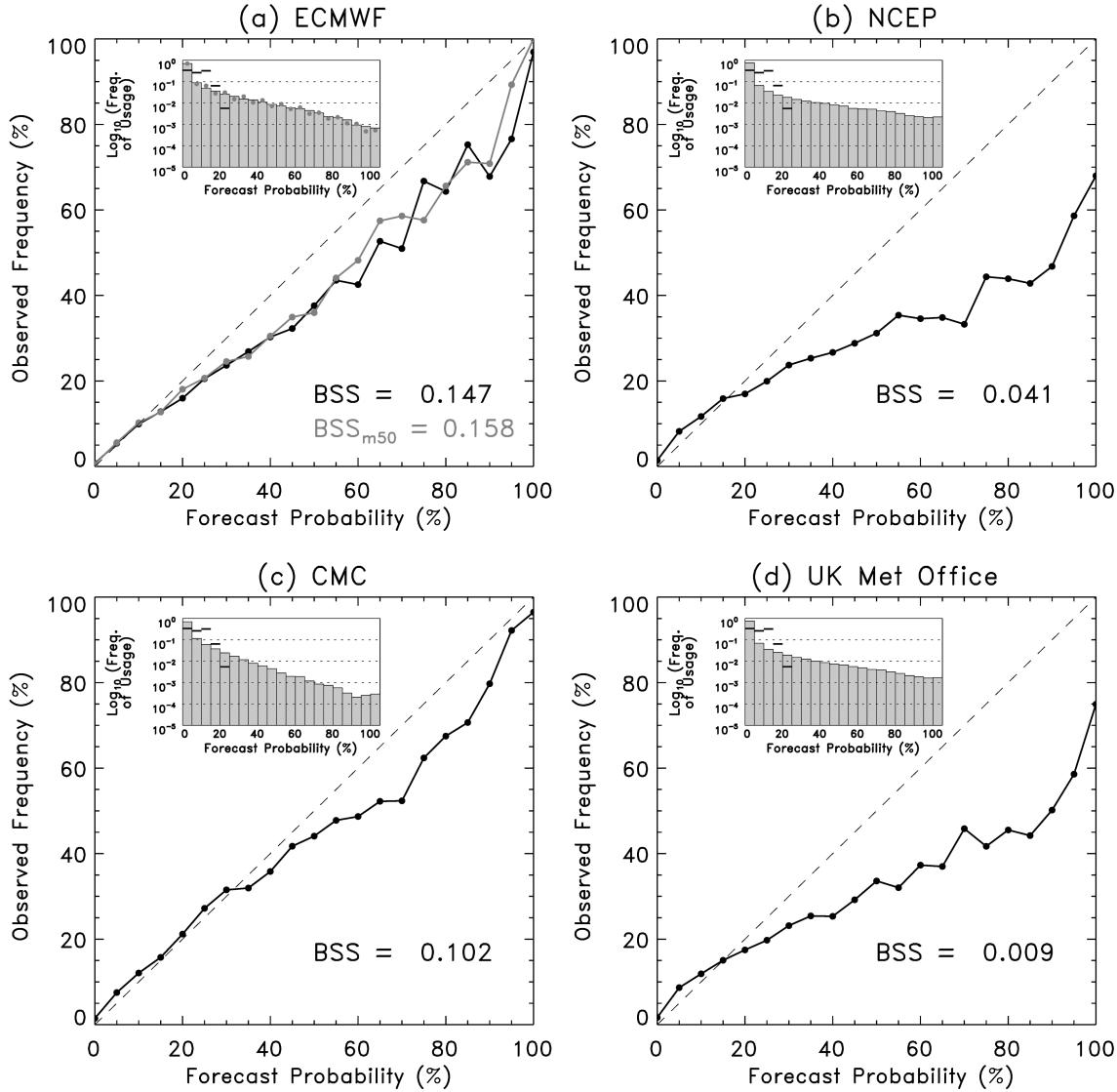
Reliability, Day +2 10.0mm

**Figure A7:** As in Fig. A1, but for the day +2 > 10-mm (24 h)⁻¹ forecast.

Reliability, Day +3 10.0mm

**Figure A8:** As in Fig. A1, but for the day +3 > 10-mm (24 h)⁻¹ forecast.

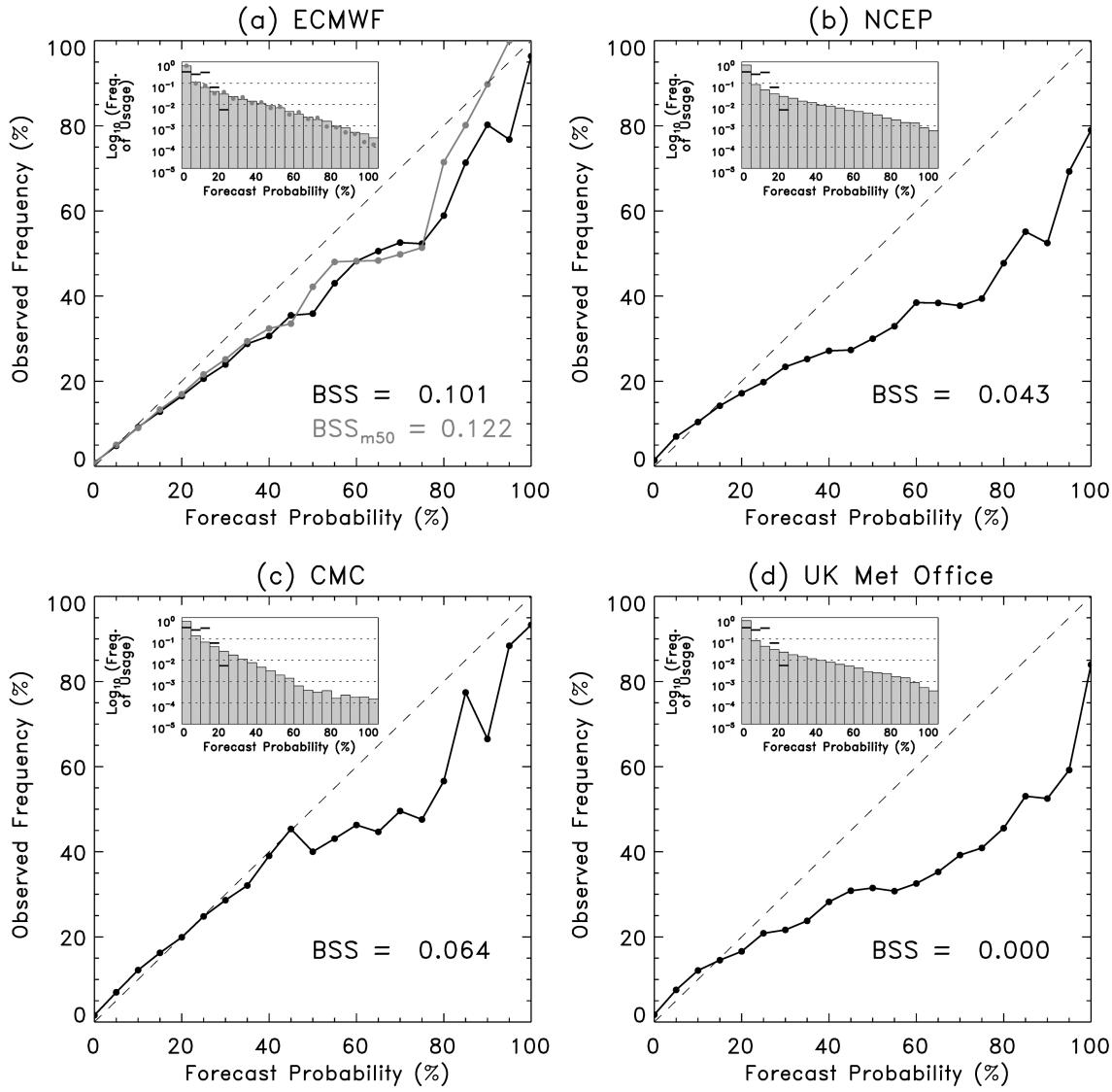
Reliability, Day +4 10.0mm

**Figure A9:** As in Fig. A1, but for the day +4 > 10-mm (24 h) $^{-1}$ forecast.

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Reliability, Day +5 10.0mm



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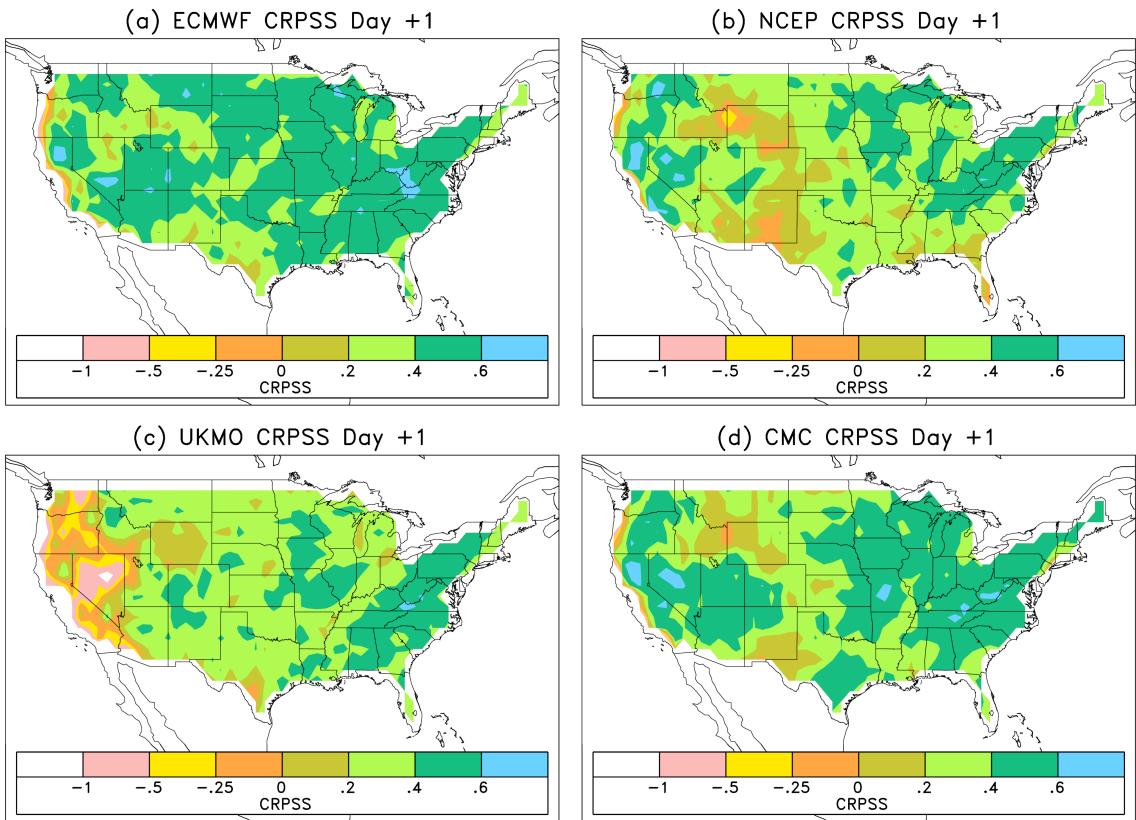
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Figure A10: As in Fig. A1, but for the day +5 > 10-mm (24 h) $^{-1}$ forecast.

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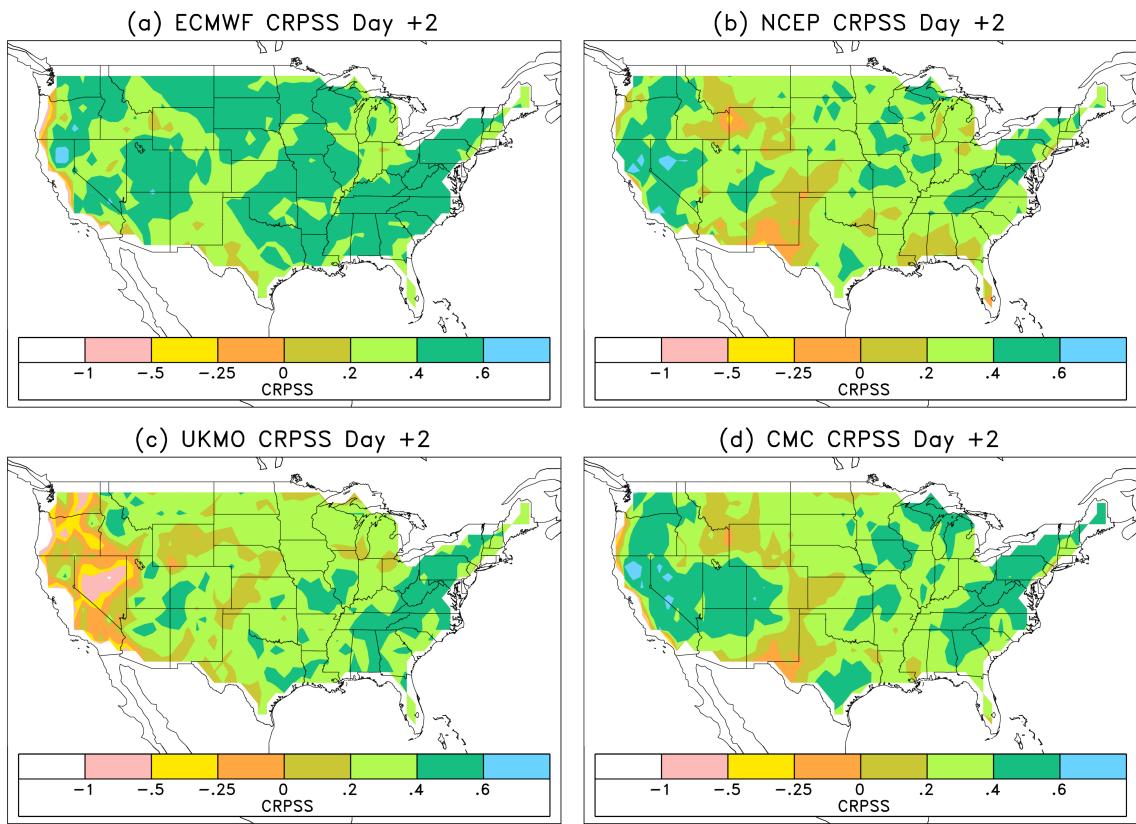
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84 **Figure A11:** Map of *CRPSS* for day +1 forecasts for (a) ECMWF, (b) NCEP, (c) UKMO,
85 and (d) CMC.

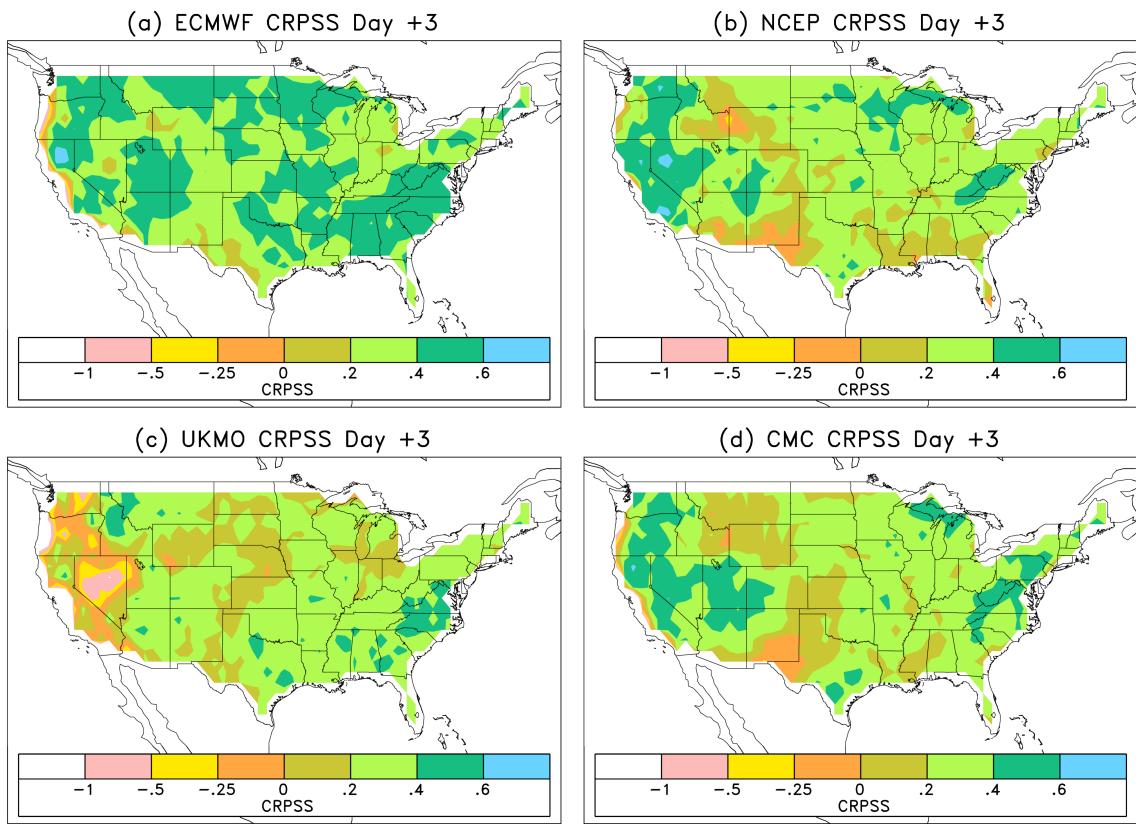
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91 **Figure A12:** Map of CRPSS for day +2 forecasts for (a) ECMWF, (b) NCEP, (c) UKMO,
92 and (d) CMC.

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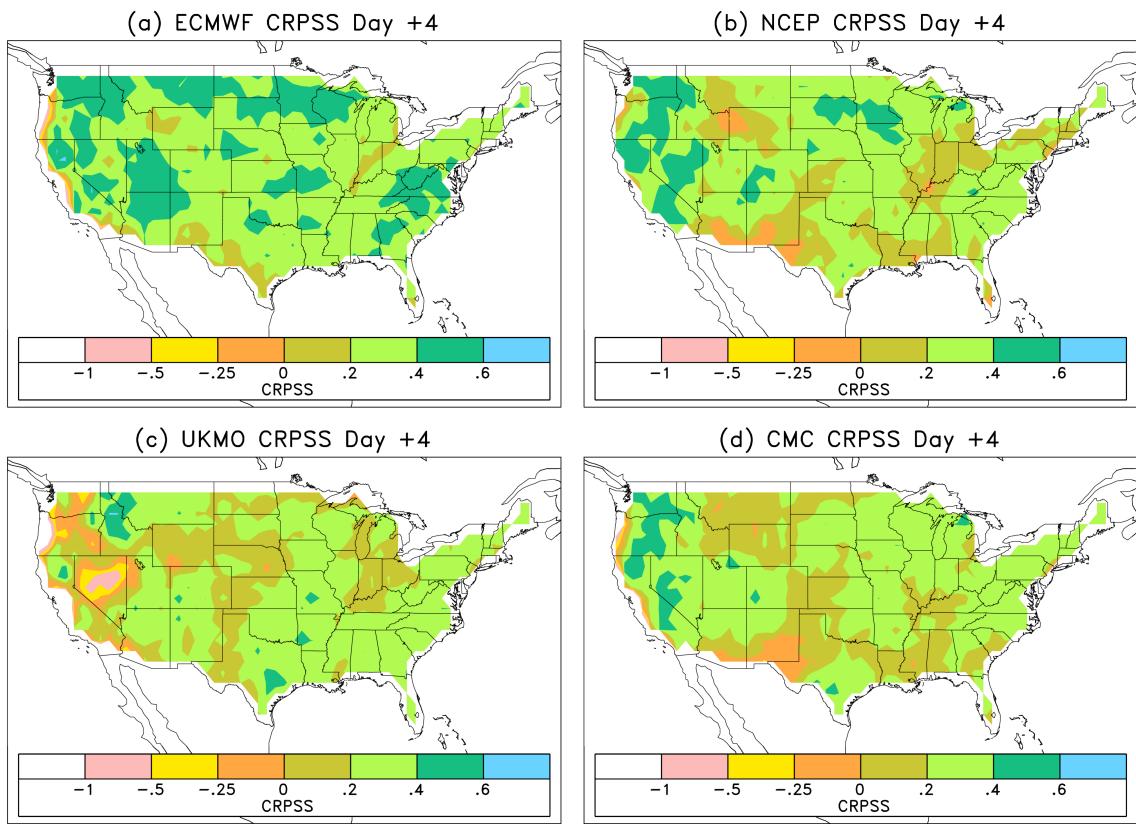
Figure A13: Map of CRPSS for day +3 forecasts for (a) ECMWF, (b) NCEP, (c) UKMO, and (d) CMC.

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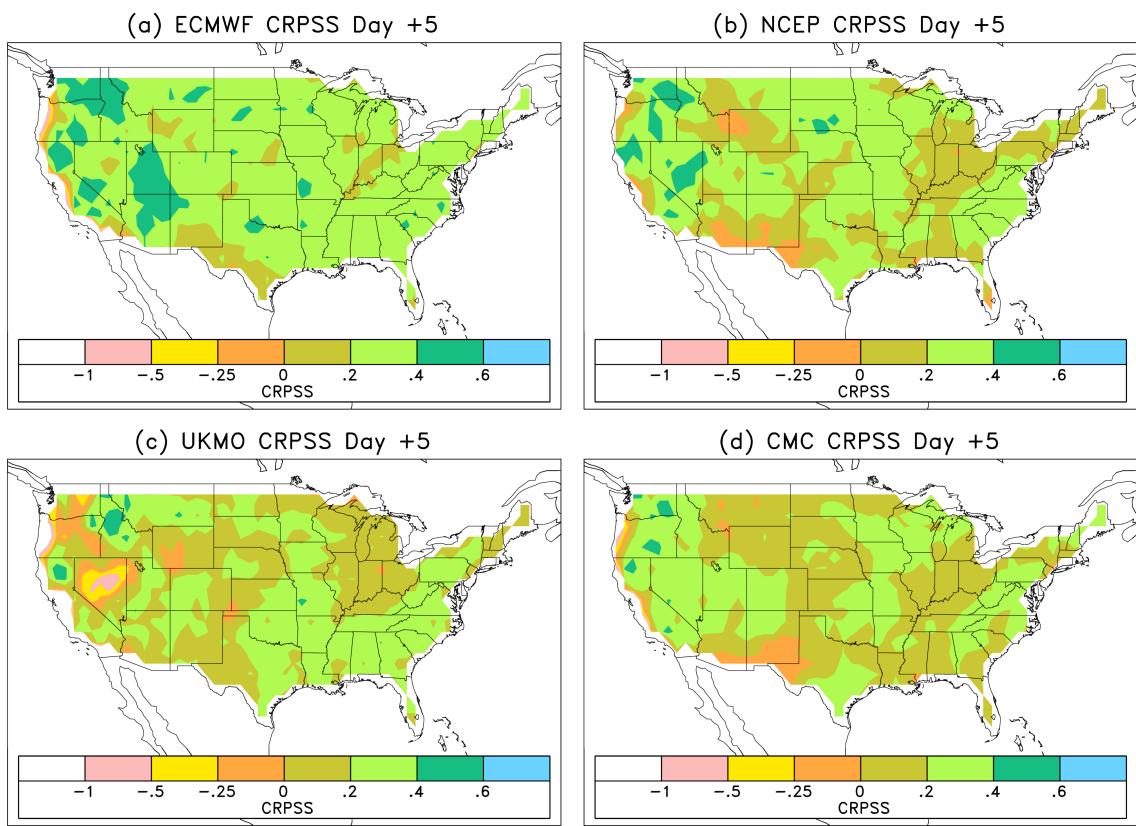
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105 **Figure A14:** Map of CRPSS for day +4 forecasts for (a) ECMWF, (b) NCEP, (c) UKMO,
106 and (d) CMC.

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112 **Figure A15:** Map of CRPSS for day +5 forecasts for (a) ECMWF, (b) NCEP, (c) UKMO,
113 and (d) CMC.

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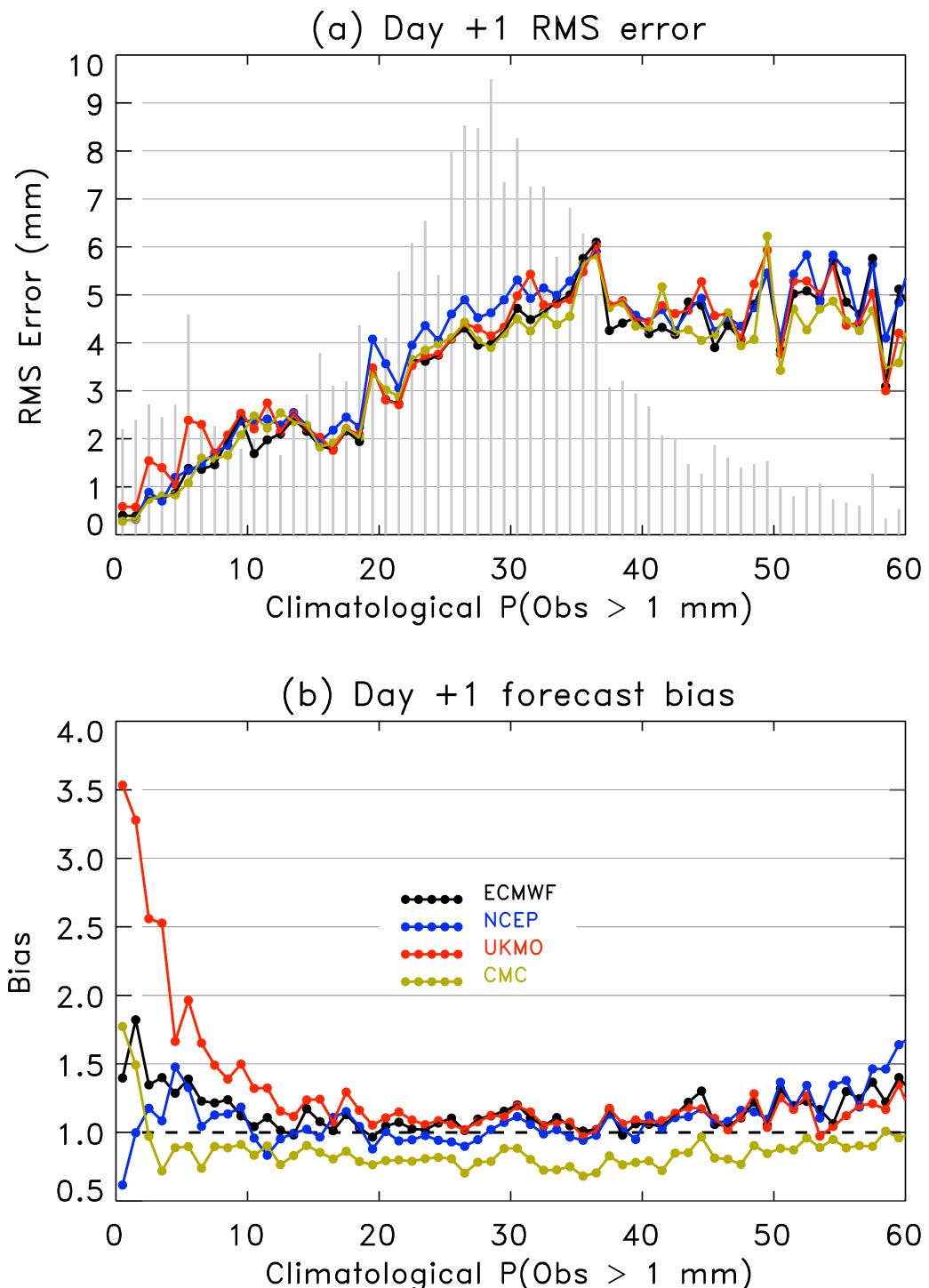
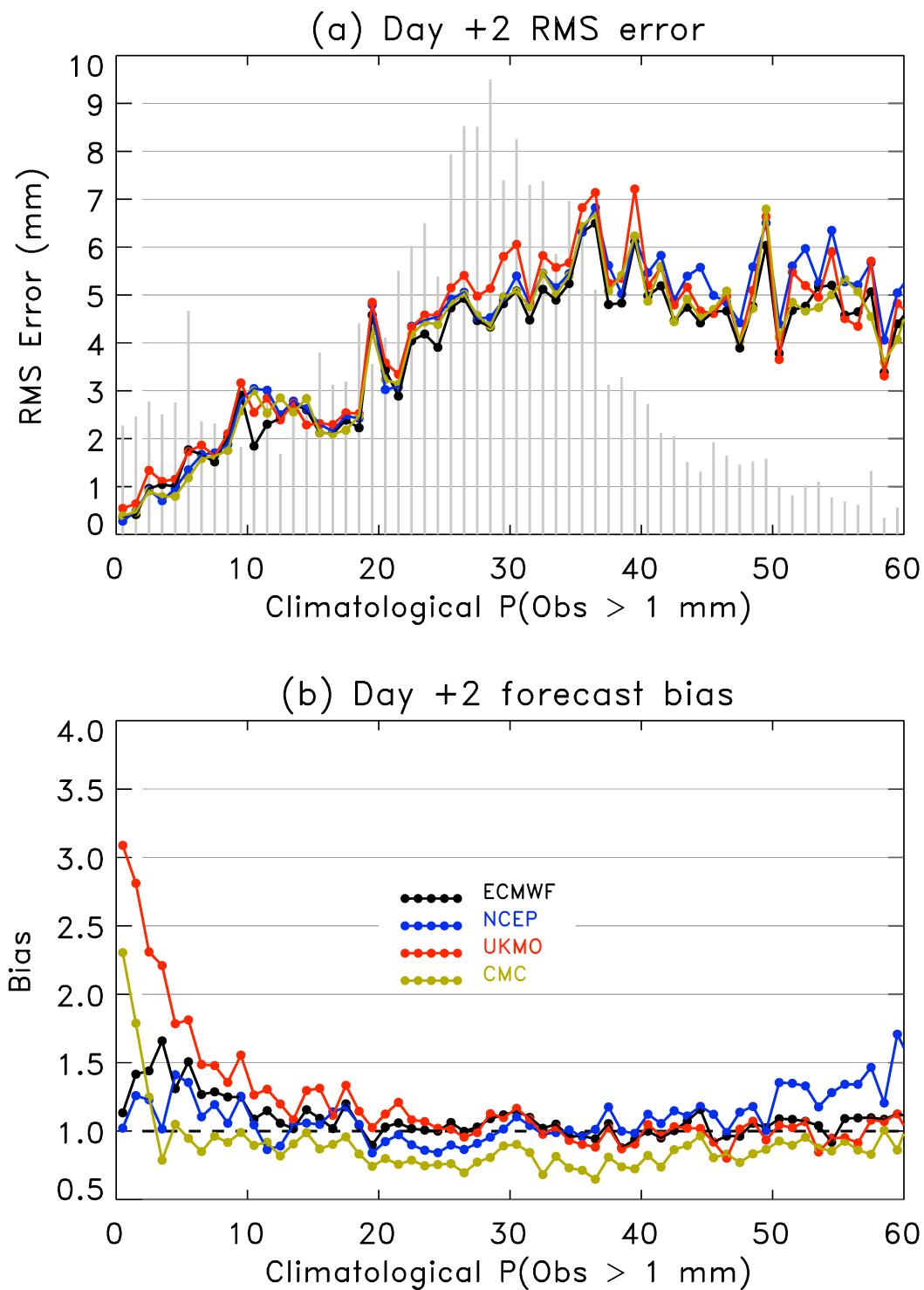


Figure A16: (a) RMS errors, and (b) bias for day +1 forecasts, both as a function of the climatological probability of $> 1\text{-mm } (24\text{ h})^{-1}$. Light grey bars in panel (a) denote the relative frequency of each climatological probability.

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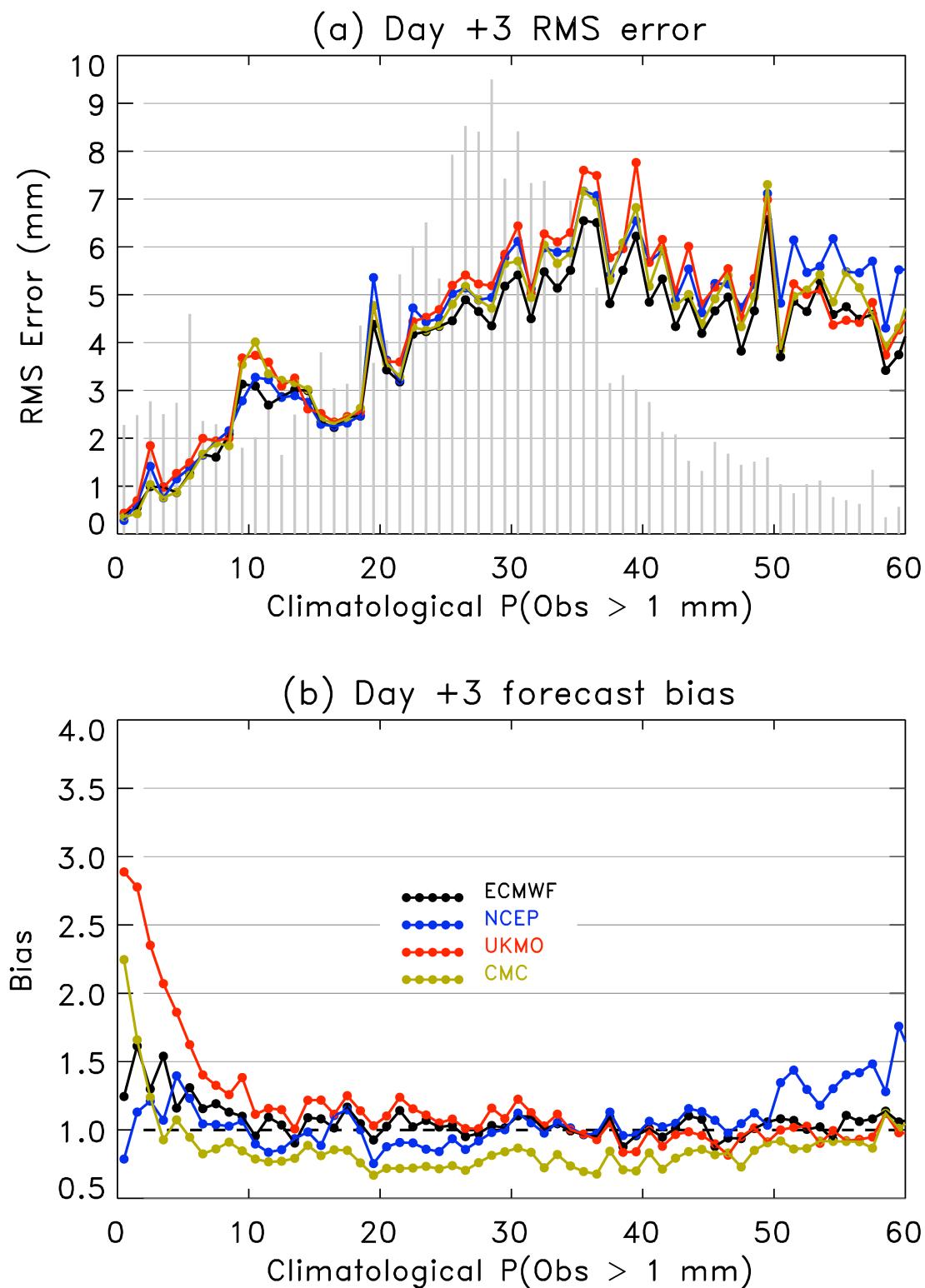
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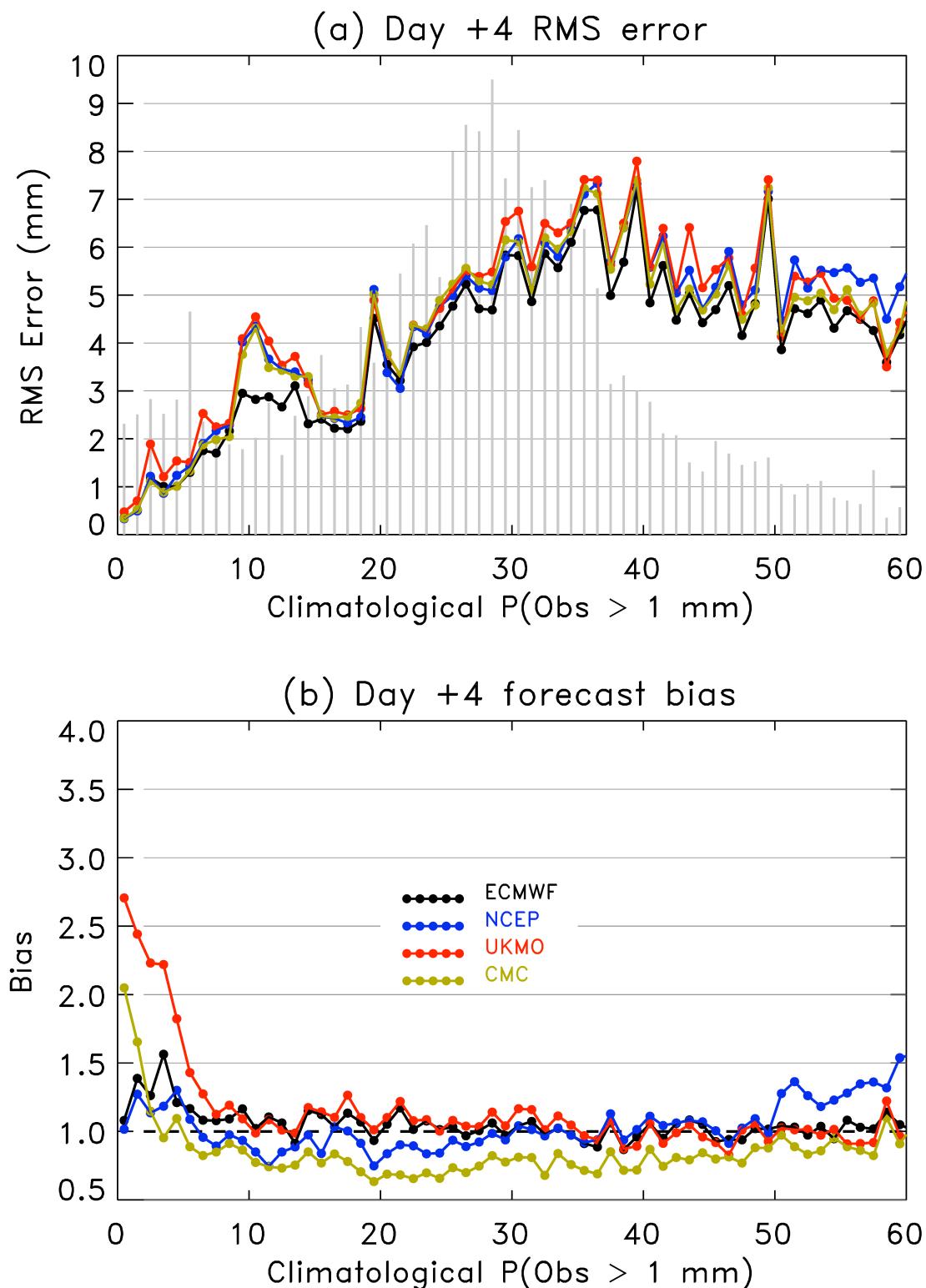
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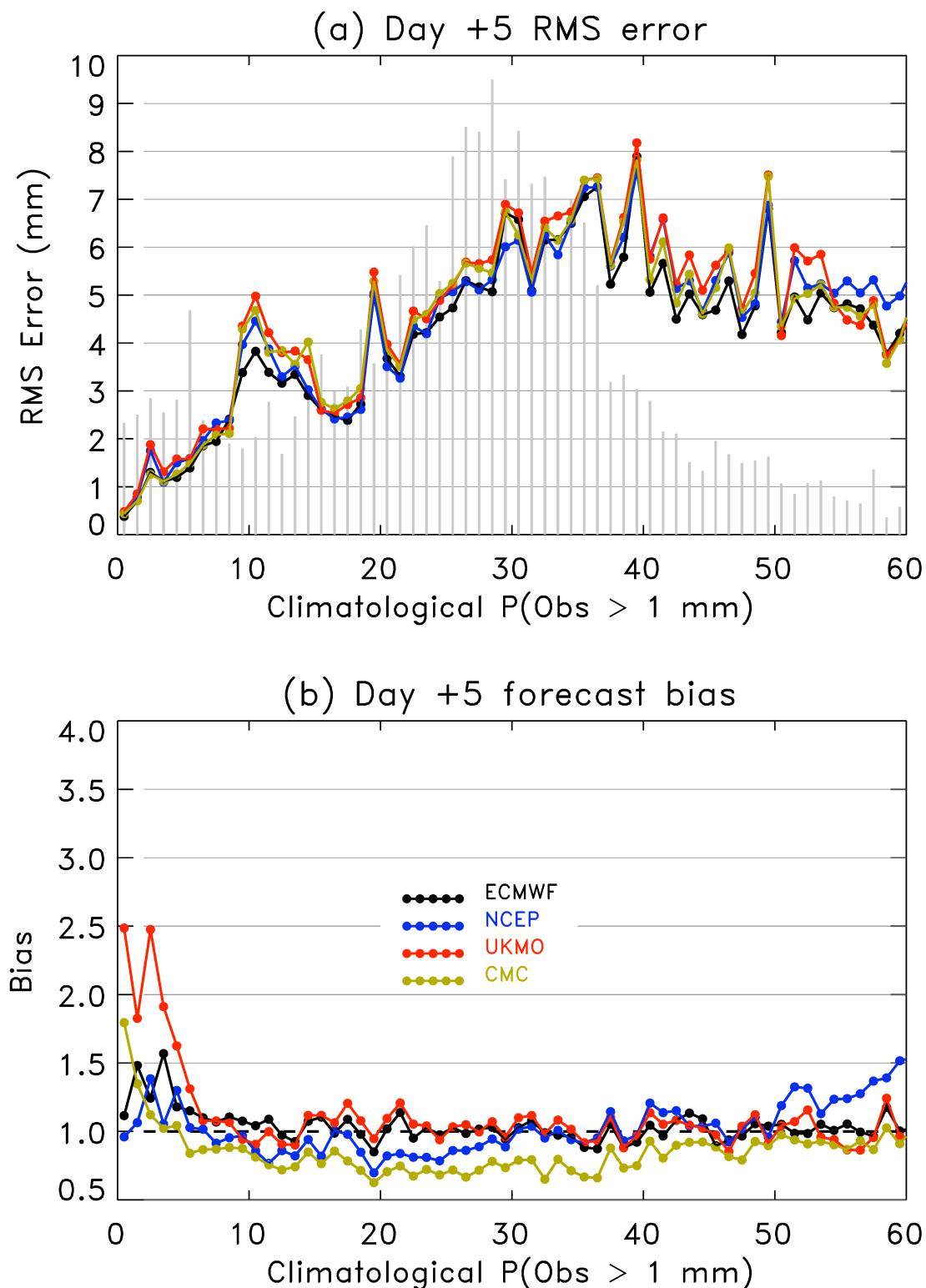
126 **Figure A17:** As in Fig. A16, but for the day +2 forecasts.

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**Figure A18:** As in Fig. A16, but for the day +3 forecasts.





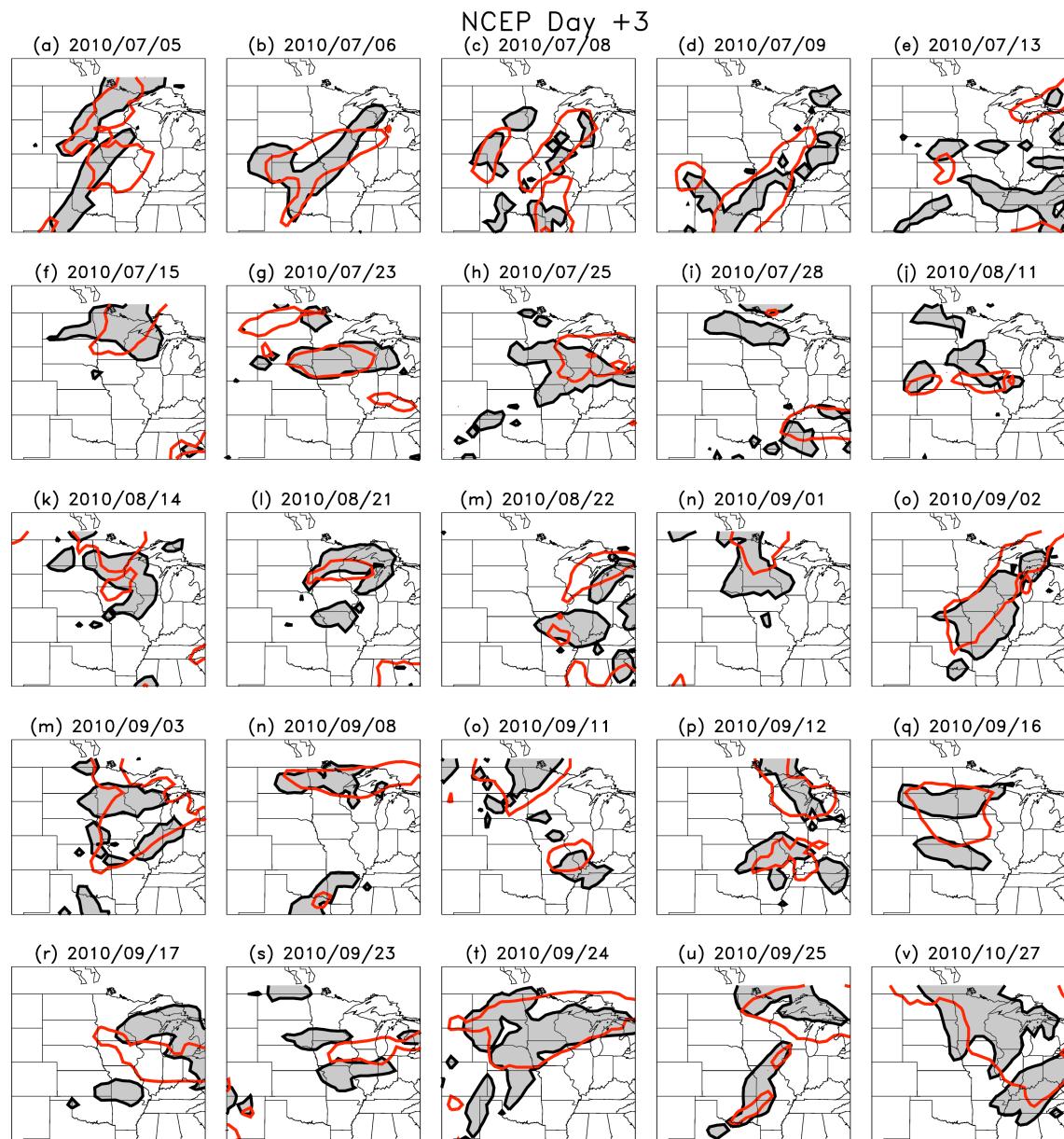
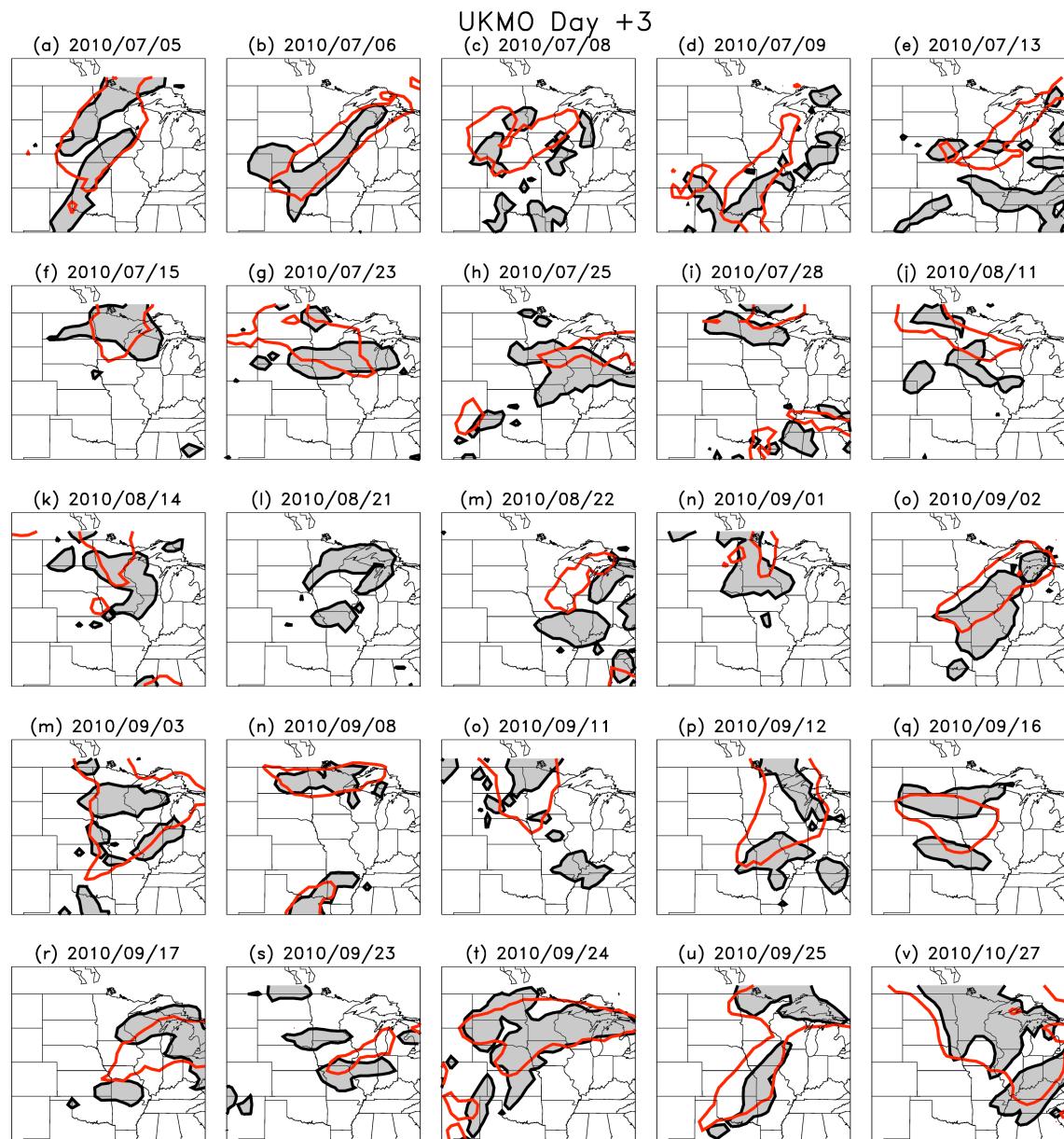


Figure A21: Observed > 10-mm 24h⁻¹ precipitation boundary (black line) and area (grey shading) for 25 cases with the largest areal coverage of greater than 10 mm in the upper Midwest US. Red lines indicate the 0.5 probability contour from the NCEP ensemble for the day +3 forecasts of > 10 mm (24 h)⁻¹.

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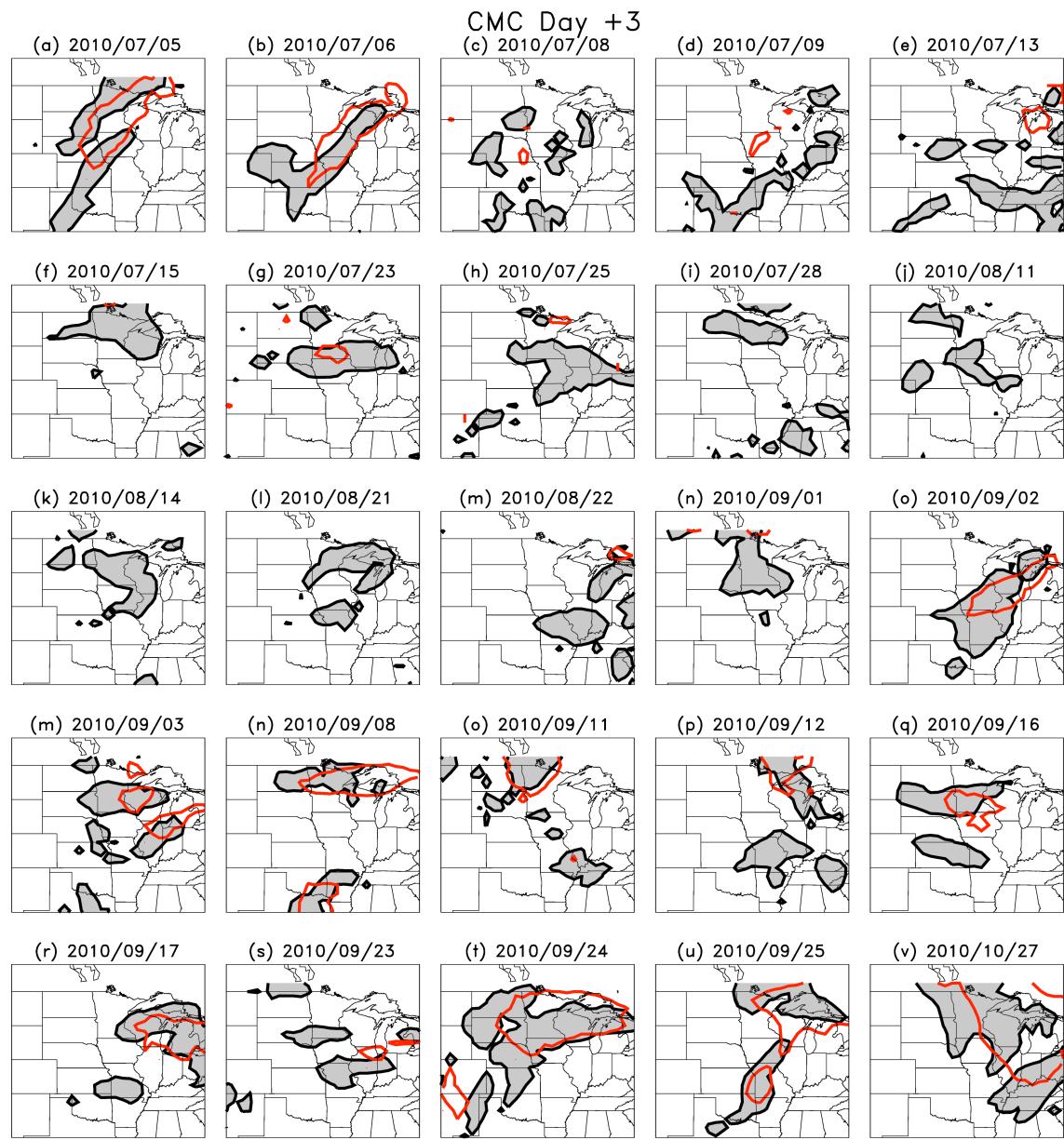
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155 **Figure A22:** As in Fig. A21, but for the UKMO day +3 forecasts.

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160 **Figure A23:** As in Fig. A21, but for the CMC day +3 forecasts.

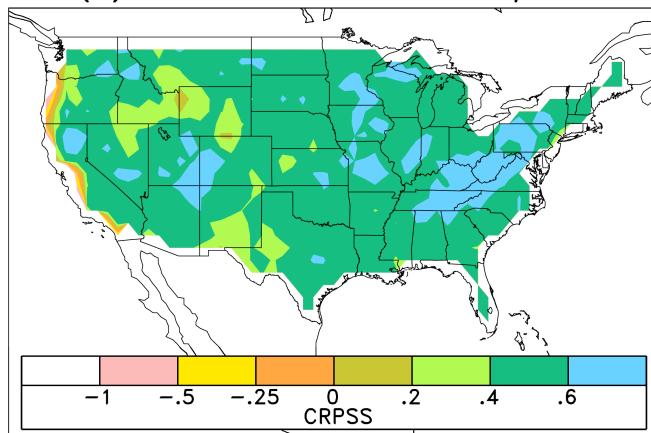
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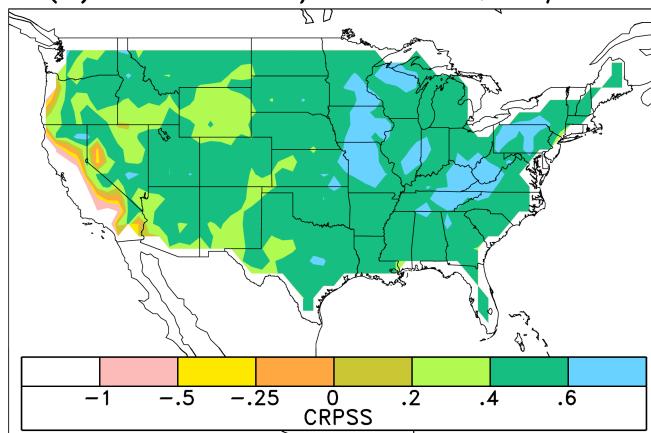
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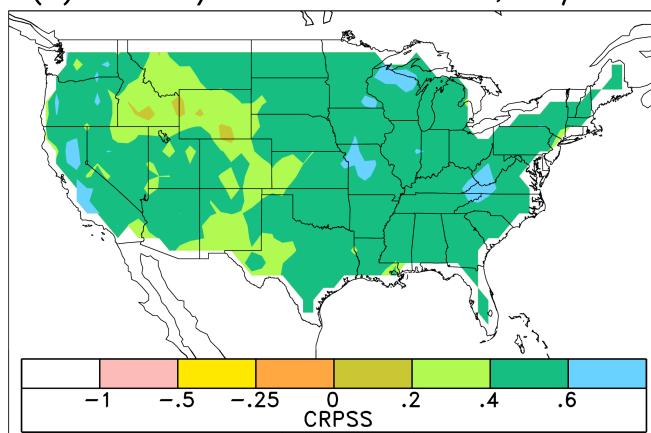
(a) Multi-model CRPSS, day +1



(b) Multi-model/calibrated, day +1



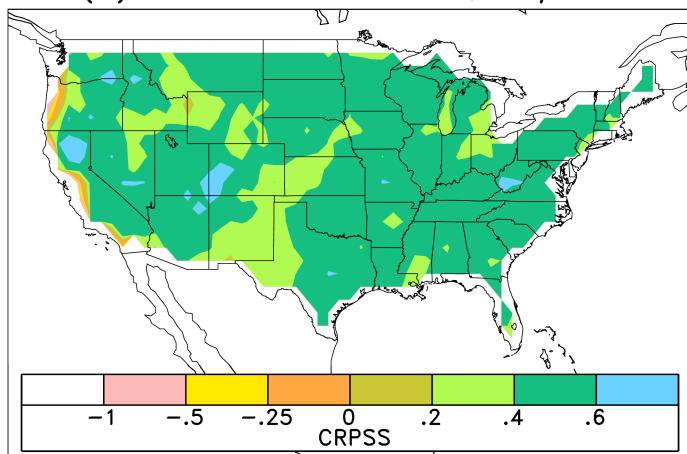
(c) ECMWF/reforecast CRPSS, day +1



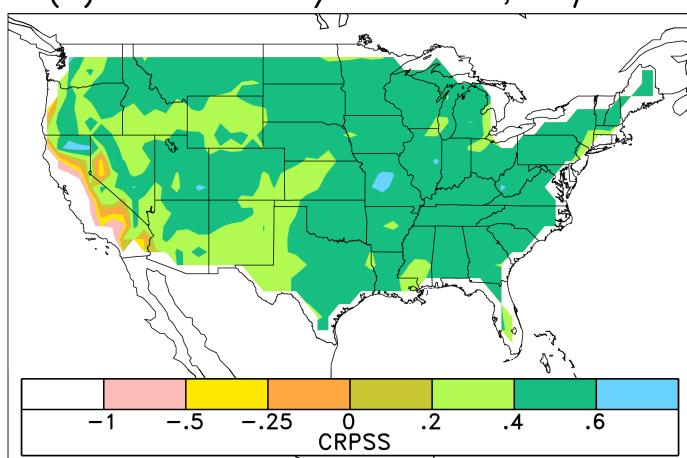
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Figure A24: CRPSS of day +1 forecasts for (a) multi-model, (b) multi-model with ELR calibration, and (c) ECMWF calibrated with reforecasts.

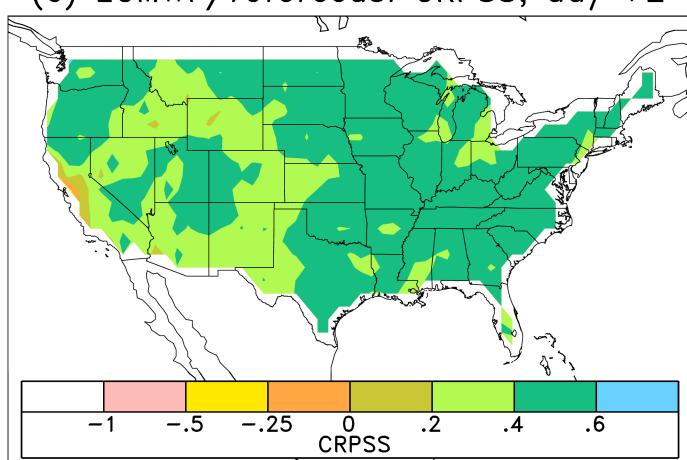
(a) Multi-model CRPSS, day +2



(b) Multi-model/calibrated, day +2



(c) ECMWF/reforecast CRPSS, day +2



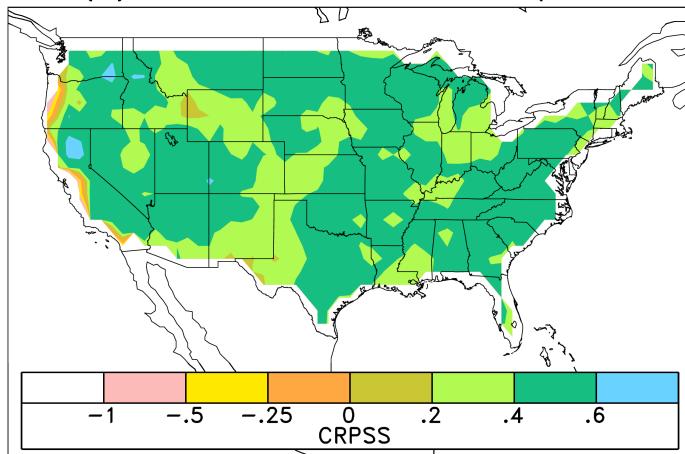
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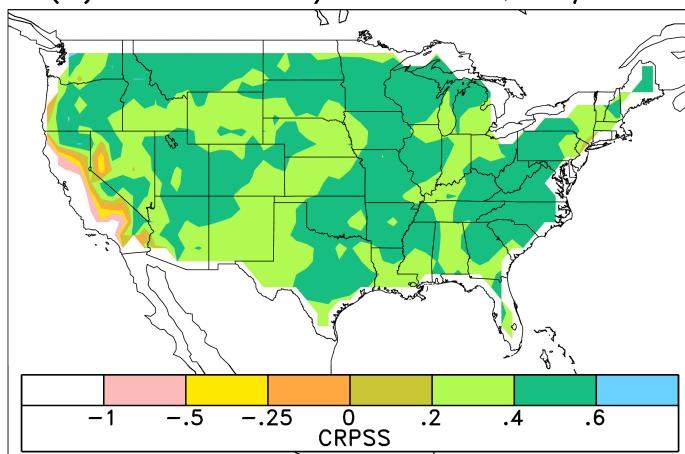
171 **Figure A25:** As in Fig. A24, but for day +2 forecasts.

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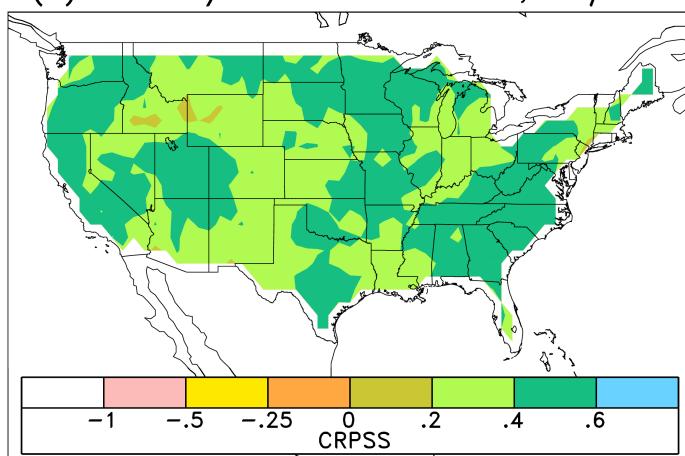
(a) Multi-model CRPSS, day +3



(b) Multi-model/calibrated, day +3



(c) ECMWF/reforecast CRPSS, day +3



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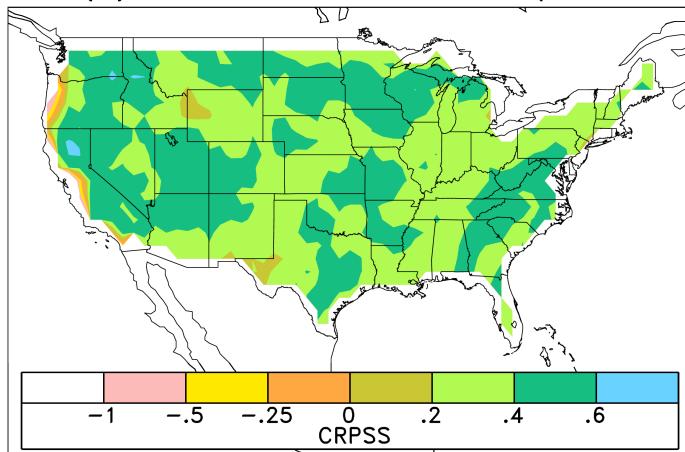
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175 **Figure A26:** As in Fig. A24, but for day +3 forecasts.

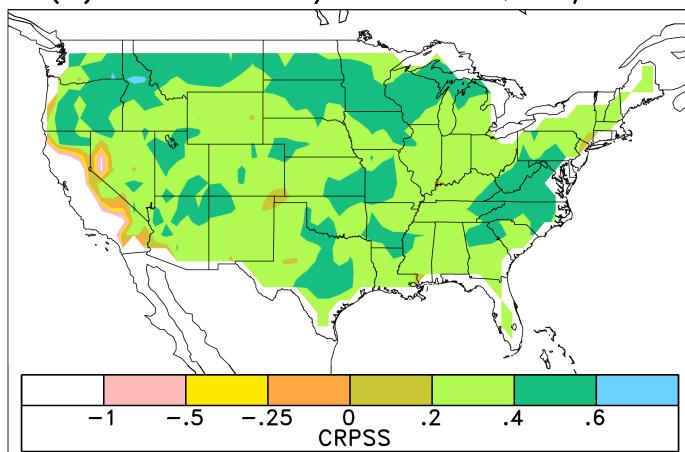
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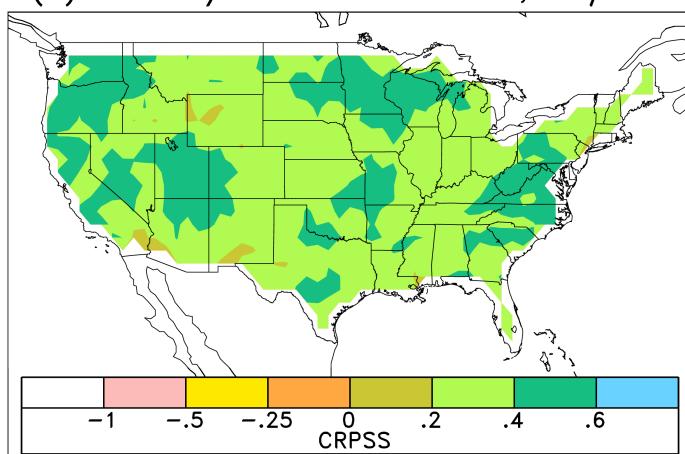
(a) Multi-model CRPSS, day +4



(b) Multi-model/calibrated, day +4



(c) ECMWF/reforecast CRPSS, day +4



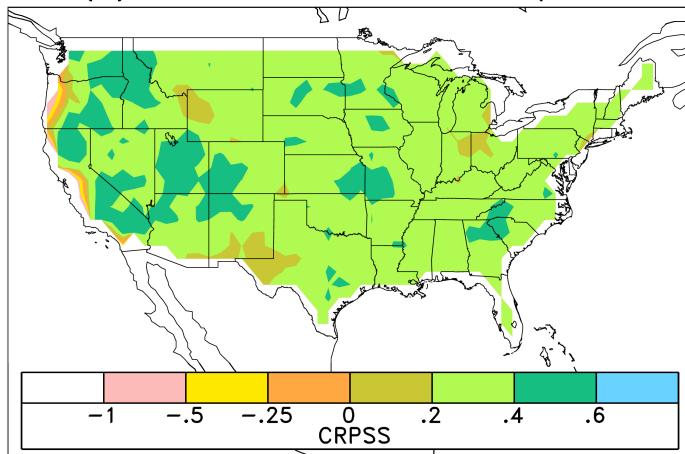
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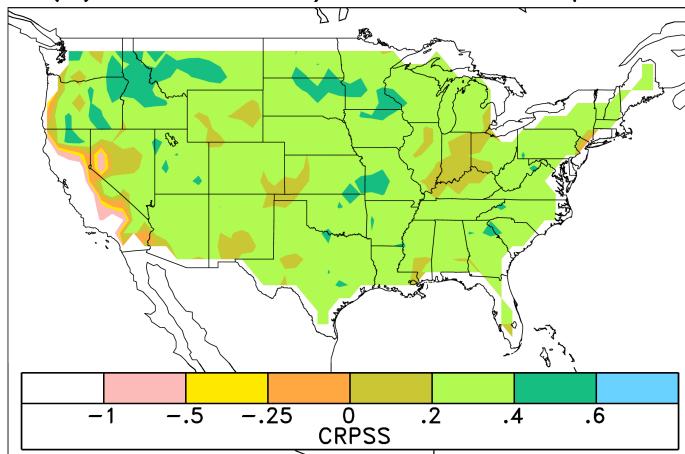
180 **Figure A27:** As in Fig. A24, but for day +4 forecasts.

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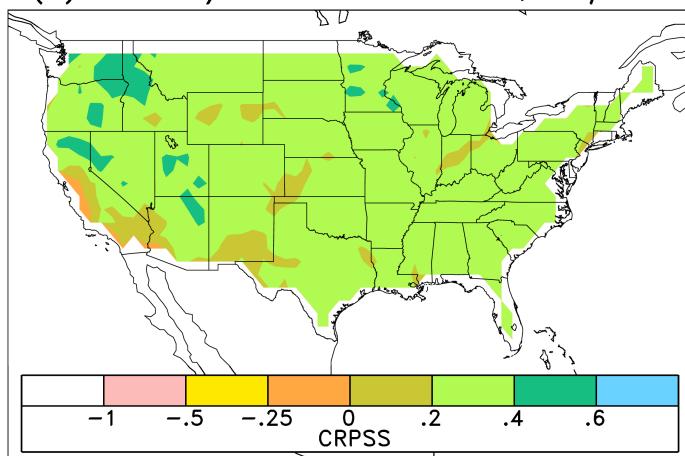
(a) Multi-model CRPSS, day +5



(b) Multi-model/calibrated, day +5



(c) ECMWF/reforecast CRPSS, day +5



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Figure A28: As in Fig. A24, but for day +5 forecasts.

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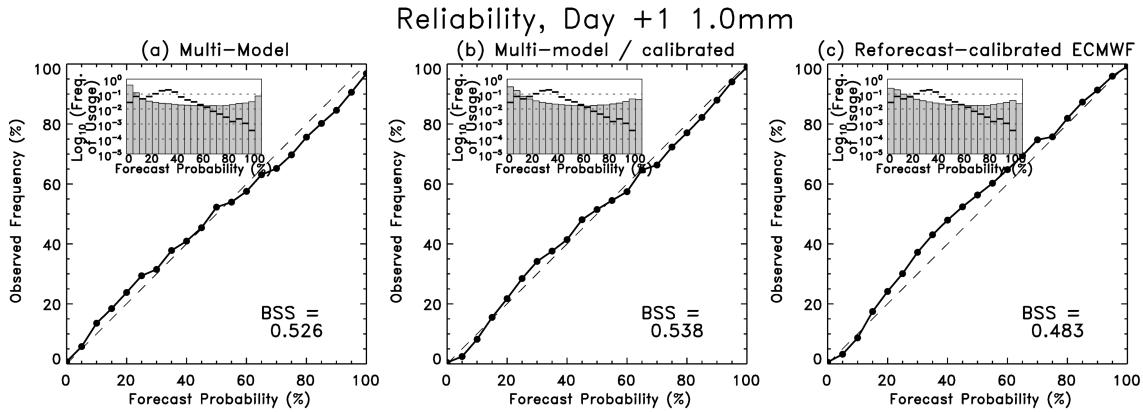


Figure A29: Reliability diagrams as in Fig. A1, but for $> 1.0 \text{ mm} (24 \text{ h})^{-1}$ day +1 forecasts from (a) multi-model, (b) multi-model with ELR calibration, and (c) ECMWF calibrated with ELR using reforecasts.

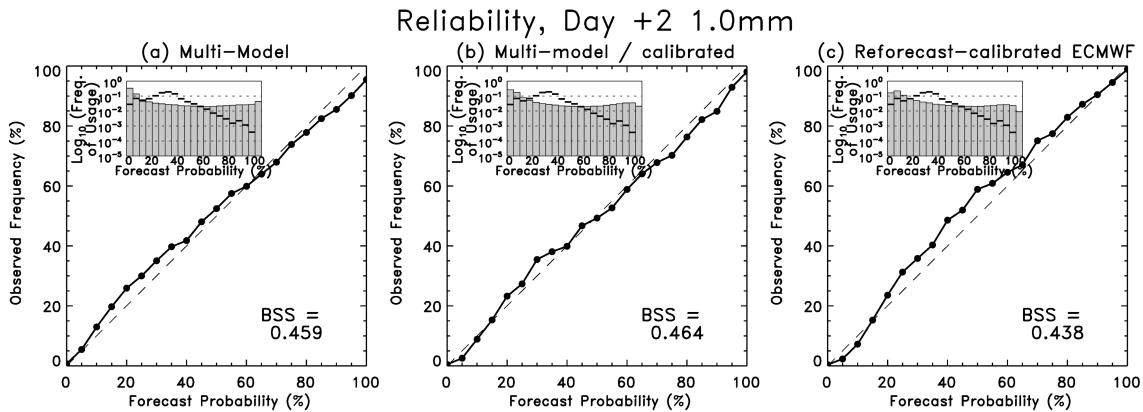


Figure A30: As in Fig. A29, but for day +2 forecasts.

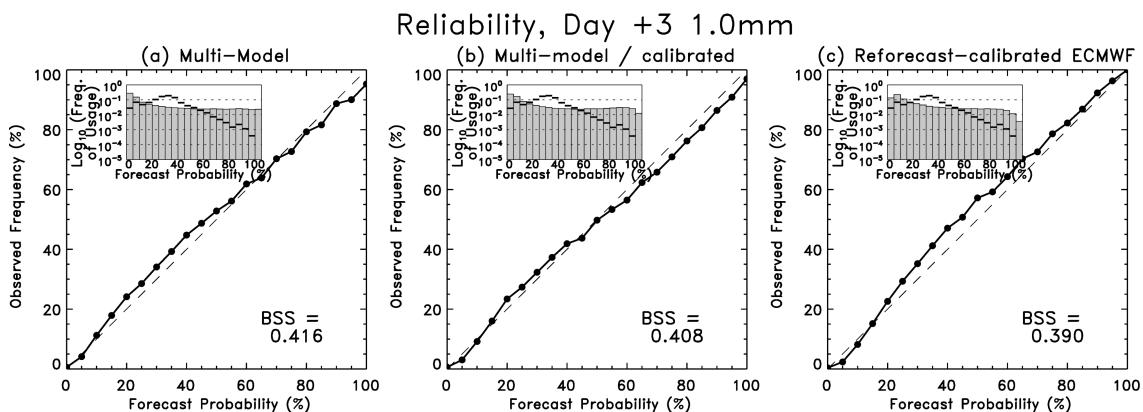
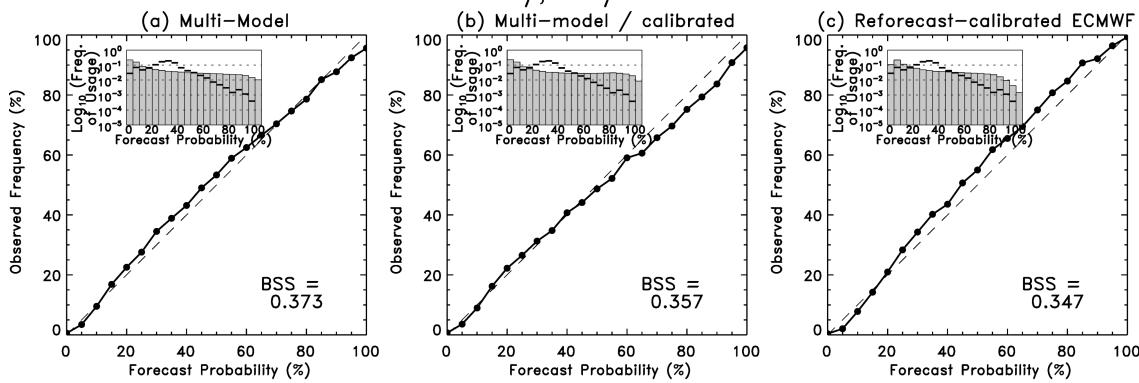


Figure A31: As in Fig. A29, but for day+3 forecasts.

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Reliability, Day +4 1.0mm



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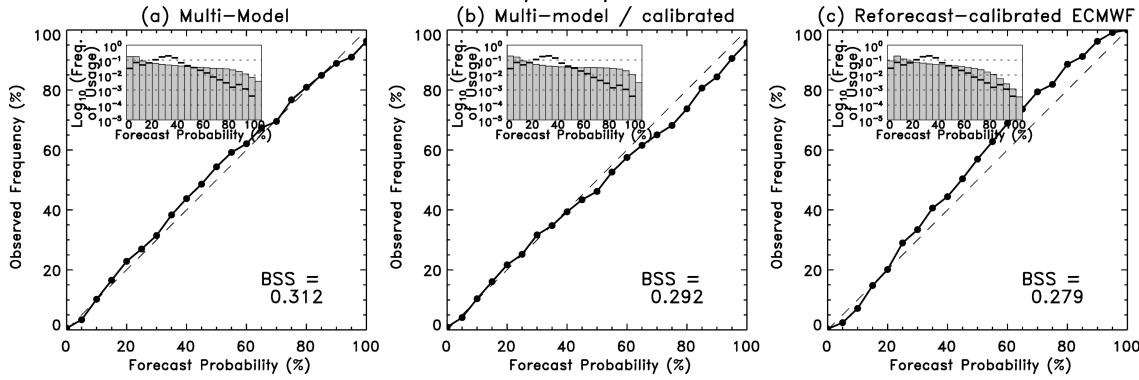
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Figure A32: As in Fig. A29, but for day +4 forecasts.

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Reliability, Day +5 1.0mm



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Figure A33: As in Fig. A29, but for day +5 forecasts.

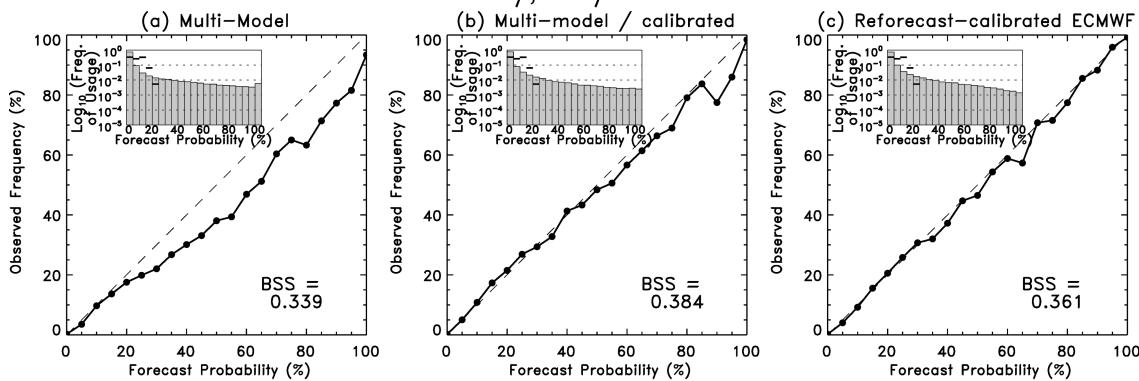
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Reliability, Day +1 10.0mm



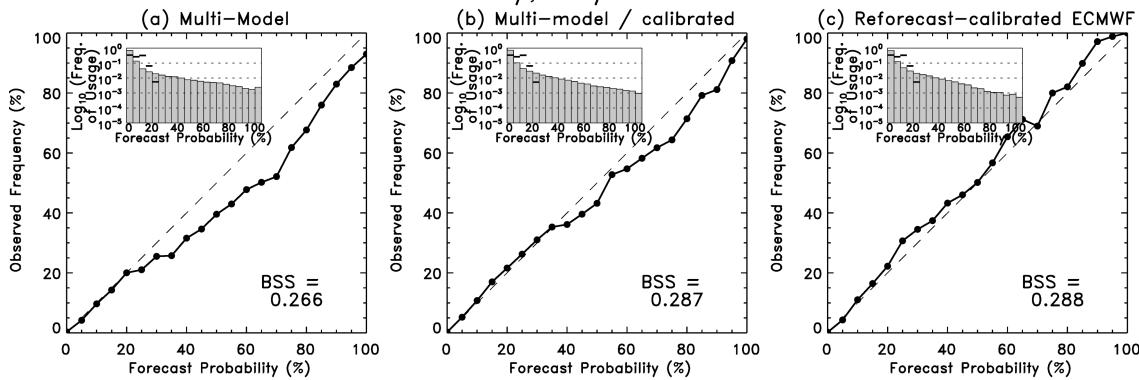
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Figure A34: As in Fig. A29, but for > 10.0-mm (24 h) $^{-1}$ day +1 forecasts.

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Reliability, Day +2 10.0mm



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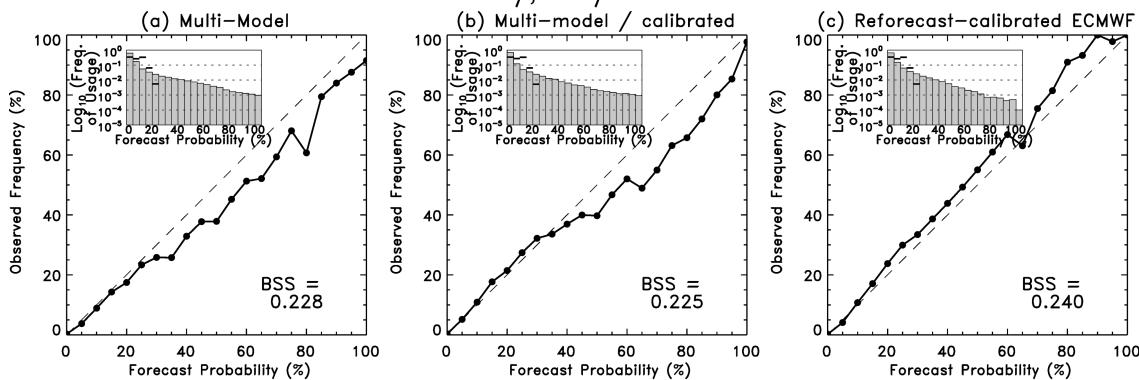
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Figure A35: As in Fig. A29, but for > 10.0-mm (24 h) $^{-1}$ day +2 forecasts.

Reliability, Day +3 10.0mm



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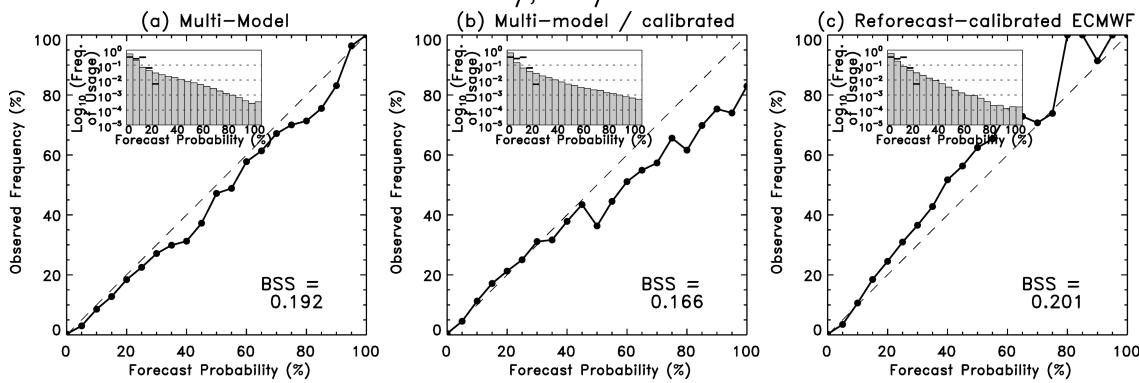
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Figure A36: As in Fig. A29, but for > 10.0-mm (24 h) $^{-1}$ day +3 forecasts.

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Reliability, Day +4 10.0mm



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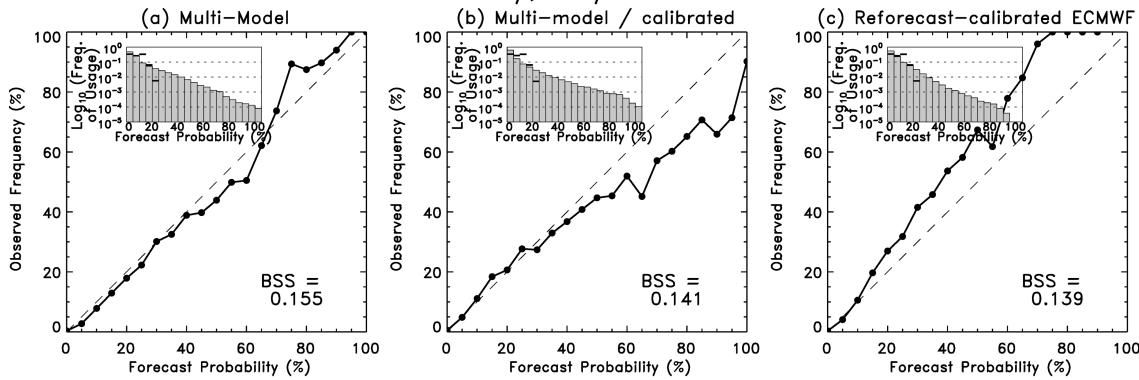
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Figure A37: As in Fig. A29, but for > 10.0-mm (24 h)⁻¹ day +4 forecasts.

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Reliability, Day +5 10.0mm



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Figure A38: As in Fig. A29, but for > 10.0-mm (24 h)⁻¹ day+5 forecasts.

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